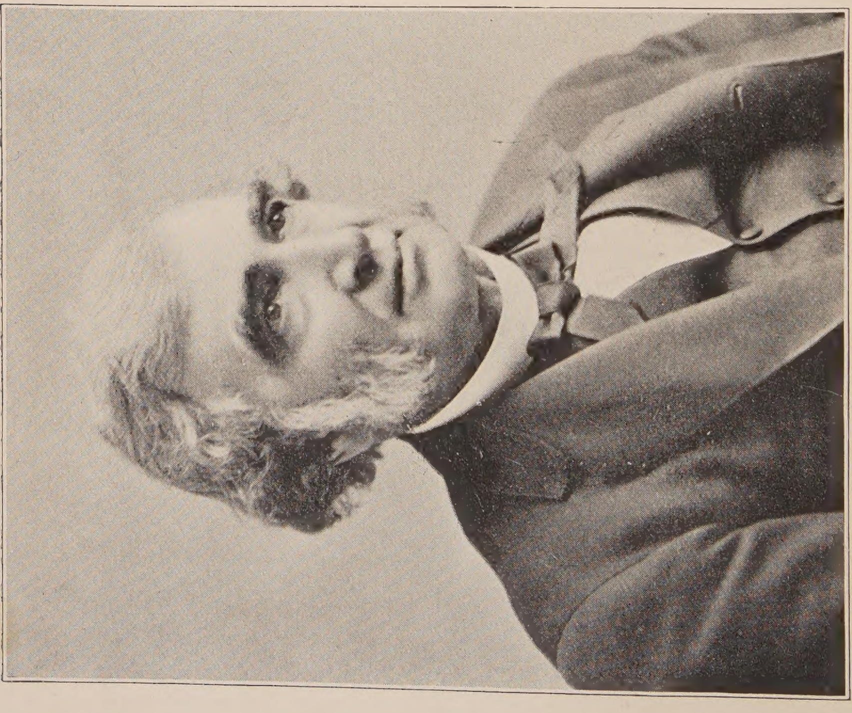

SENATOR J. S. MORRILL.
(Father of the Agricultural and Mechanical Colleges.)

HON. WILLIAM H. HATCH.
(Father of the Agricultural Experiment Stations. Died August 1, 1895.)

YEARBOOK

OF THE

UNITED STATES

DEPARTMENT OF AGRICULTURE.

1896.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1897.

[PUBLIC—No. 23.]

AN ACT providing for the public printing and binding and distribution of public documents.

* * * * * * *

Section 73, paragraph 2:

The Annual Report of the Secretary of Agriculture shall hereafter be submitted and printed in two parts, as follows: Part one, which shall contain purely business and executive matter which it is necessary for the Secretary to submit to the President and Congress; part two, which shall contain such reports from the different bureaus and divisions, and such papers prepared by their special agents, accompanied by suitable illustrations, as shall, in the opinion of the Secretary, be specially suited to interest and instruct the farmers of the country, and to include a general report of the operations of the Department for their information. There shall be printed of part one, one thousand copies for the Senate, two thousand copies for the House, and three thousand copies for the Department of Agriculture; and of part two, one hundred and ten thousand copies for the use of the Senate, three hundred and sixty thousand copies for the use of the House of Representatives, and thirty thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Secretary of Agriculture; and the title of each of the said parts shall be such as to show that such part is complete in itself.

PREFACE.

In presenting the Yearbook of the Department of Agriculture for 1896 to farmers and others interested in the subject of agriculture, it is hoped that it may, in a measure at least, fulfill whatever expectations have been aroused by the two preceding volumes. When the Annual Report of the United States Department of Agriculture first appeared in this form, the hope was expressed that future numbers of the book would still more fully justify the new departure. It is therefore hoped that no backward step is evidenced in the present volume and that the work may indicate a steady growth toward the ideal which has been continually in mind, but which is as yet so far short of attainment.

The Yearbook is in many respects unique. A bound volume of over six hundred pages, published annually in an edition of 500,000 copies, and for free distribution, there is not another publication like it. Its small beginning and enormous growth make its history an interesting one. The Agricultural Report, of which the Yearbook is the successor, was first published in a separate volume as Part II of the Annual Report of the Commissioner of Patents. The volume in its original form was made up almost wholly of business reports for the use of Congress, but when it began to be distributed to an increasing extent among farmers it became the custom to introduce into it, for the benefit of its rural readers, popular papers on agriculture or discussions of the results of scientific investigations. In 1849 the agricultural part of the report had assumed such proportions as to be issued in a separate volume. Of this report in 1851, 110,000 copies were ordered, 100,000 of which were distributed by Congress. After the Bureau became one of the eight Executive Departments of the Government, in 1889, the editions of the report greatly increased with the growth of the population of the country and the development of its various agricultural interests, until now the Yearbook is published in annual editions of half a million copies.

In its gradual development, and as the editions of the report in its old form grew still larger, the book was more and more regarded as a popular report, so that the business and executive matter was reduced to the smallest possible proportions. Finally, in 1895, Congress passed a law (an extract from which appears on the preceding page) requiring that future annual reports of the Department should be divided into two parts: (1) An executive and business report, containing "purely business and executive matter which it is necessary for the Secretary to submit to the President and Congress," and (2) a volume made up of papers "specially suited to interest and instruct the farmers of the country," and to include also "a general report of the operations

of the Department for their information." The executive report is published separately in the series of Messages and Documents, and the second part is published as the Yearbook of the Department of Agriculture.

Confining our attention now to the scope of this volume, it will be seen that the report of the Secretary of Agriculture to the President fulfills the requirement of the law for a general report on the operations of the Department. The second portion of the volume is made up of a series of papers from the Department bureaus and divisions and from some of the experts of the agricultural experiment stations, discussing the results of their investigations in agricultural science or their trials in farm practice. With the object of making the book attractive as well as instructive, these papers are illustrated as fully as possible, and are presented in the form of popular essays rather than as scientific reports expressed in technical language. While no attempt at systematic treatment of points in agricultural science has been made, it is intended that the farmer who receives this volume and preserves it carefully with the volumes which have preceded and will follow it, will in the course of a few years accumulate a fairly complete and useful library of agricultural science and practice. As a means of perpetuating in convenient form the agricultural statistics collected by the Department, an Appendix occupies the concluding portion of the book, in which these statistics are condensed, together with much valuable material, in the form of recipes and directions, with regard to horticultural practice. It has been the purpose thus to make the Appendix a vade mecum for the farmer, and the series of Yearbooks, which are thoroughly indexed for this purpose, a reference library of increasing value to the agriculturist.

The undersigned has been assisted in the selection and editing of papers by many officers of the Department, but he is especially indebted to Mr. John Hyde, statistical expert of the Department, for careful and skillful assistance in selecting and revising manuscripts and illustrations submitted for the book.

The experience gained in the preparation of this and the two preceding volumes of the Yearbook leads to the suggestion here that a work of this scope, and published in such large editions, should have the attention of a board of editors with a corps of special writers. As a matter of fact, the material for this and the preceding books has been prepared by busy scientific workers in the intervals of other duties, and has received only such editorial revision as was possible for an executive officer and one assistant to give it. While the work still falls far short of the ideal set for it, it is hoped that it will be accepted by the farming public as the best that can be produced under present conditions, and the hope and belief are expressed that those who take up the work here laid down will be able to make it better with each succeeding number.

CHARLES W. DABNEY, JR.,
Assistant Secretary.

WASHINGTON, D. C., *February 1, 1897.*

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YEARBOOK

OF THE

U. S. DEPARTMENT OF AGRICULTURE

REPORT OF THE SECRETARY.

Mr. PRESIDENT:

The Secretary of Agriculture has the honor to submit his fourth annual report, covering the doings of the Department for the fiscal year ending June 30, 1896, together with some recommendations for the improvement of its work and the extension of its usefulness.

APPROPRIATIONS AND EXPENDITURES—SAVINGS.

From March 7, 1893, to October 1, 1896, the United States Department of Agriculture disbursed seven million three hundred and five thousand six hundred and thirty-seven dollars and ninety cents ($7,305,637.90). Of this sum, eight hundred and sixty thousand and nineteen dollars and ninety-eight cents ($860,019.98) were paid from the appropriations for the fiscal year which ended June 30, 1893, and which aggregated two million five hundred and forty thousand and sixty dollars and seventy-two cents ($2,540,060.72).

From this last sum were saved and covered back into the Treasury one hundred and eighty-four thousand six hundred and thirty dollars and forty-seven cents ($184,630.47).

Of the 1894 appropriation—for the fiscal year ending June 30, 1894—which amounted to two million six hundred and three thousand five hundred dollars ($2,603,500), there were covered back into the Treasury six hundred and twenty-six thousand and thirty dollars and seventy-two cents ($626,030.72).

From the money appropriated for the fiscal year 1895, amounting to two million four hundred and ninety-nine thousand and twenty-three dollars ($2,499,023), four hundred and eighty-six thousand dollars ($486,000[1]) are unexpended. Thus, from the appropriations for three years there have been returned to the United States Treasury one million two hundred and ninety-six thousand six hundred and sixty-one dollars and nineteen cents ($1,296,661.19), and there will be

[1] In round numbers; accounts not yet closed.

a remainder of four hundred and ninety thousand dollars ($490,000[1]) from the appropriation of two million five hundred and eighty-three thousand seven hundred and fifty dollars ($2,583,750) for the fiscal year ending June 30, 1896. There will also be covered into the Treasury about two hundred and eighty thousand dollars ($280,000[1]) from the appropriation for the current fiscal year 1897, amounting to two million four hundred and forty-eight thousand five hundred and thirty-two dollars ($2,448,532). Thus there will have been covered back into the Treasury since March 7, 1893, two million sixty-six thousand six hundred and sixty-one dollars and nineteen cents ($2,066,661.19) out of a total amount of eleven million one hundred and seventy-nine thousand four hundred and fifty-five dollars and forty-five cents ($11,179,455.45) on hand and appropriated.

That these great economies have been effected without in any way marring the efficiency of the Department work or unduly limiting its scope is due in a very large degree to the application of civil-service rules both in letter and spirit. The wide extension of the civil-service classification under the law has been proved by experience to be not only a great help but absolutely indispensable to the maintenance of an economical and efficient administration of the public service.

CIVIL SERVICE IN THE DEPARTMENT.

Since March 7, 1893, the classified service has been extended until it includes every important permanent position in the United States Department of Agriculture. Reports from the chiefs of bureaus and divisions since this classification are unanimous in praising the enhanced value of the service rendered by their assistants and employees. In efficiency and economy the classification has very visibly improved the work.

This Department has for its object the discovery, investigation, development, and utilization of the agricultural resources of the United States. Primarily it is a scientific or technical Department. Its most important agencies are its scientific bureaus, divisions, and surveys. There are two large bureaus and twenty-two divisions, offices, or surveys. Of these, seven are administrative, eight technical, and seven are purely scientific.

The Weather Bureau includes three business offices, six technical divisions, five scientific experts engaged in meteorological research, besides 154 observer stations and 52 signal stations along the coast and on the Great Lakes.

The Bureau of Animal Industry includes two business offices, 152 technical stations engaged in meat inspection and quarantine work, and three laboratories for investigating the diseases of animals and the causes thereof.

[1] In round numbers; accounts not yet closed.

It is thus obvious that there are a great number of positions in the Department in which ordinary clerical persons can not be employed. There is hardly any work in the Department which can be efficiently carried on under the old spoils system of a quadrennial change in office. The functions of this Department have little or no relation to political policies or expedients. Its useful work should go ahead year after year systematically, and be modified only by the development of our agriculture and commerce.

Holding these views, the Secretary has endeavored by every legitimate means to firmly establish the civil service of the Department upon a basis of solid usefulness.

STATUS OF THE CLASSIFIED SERVICE.

March 4, 1893, there were two thousand four hundred and ninety-seven (2,497) men and women upon the pay rolls of this Department. But on November 1, 1896, there were only two thousand two hundred and seventeen (2,217) on the rolls; that is—notwithstanding an increased amount of work—there had been a reduction in the force of two hundred and eighty (280).

In the classified service March 4, 1893, there were 698. Of that number there were excepted from competitive examination 80, subject to noncompetitive examination 12, total 92; leaving subject to competitive examination 606.

On November 1, 1896, there were in the classified service 1,658, excepted from competitive examination 1, leaving subject to competitive examination 1,657. Thus an increase of 1,051 persons subject to competitive examination has been made between March 4, 1893, and November 1, 1896.

One of the first acts of the present Secretary made the position of appointment clerk of the Department subject to competitive examination, bringing it within civil-service rules, and continued thereunder the present incumbent, who had been appointed by the last Administration.

Other places were brought in as rapidly as possible. Now the classified service includes all officers, clerks, and employees of the Department, including the Chief of the Bureau of Animal Industry, chiefs of divisions, superintendents, chiefs of offices, State statistical agents, experts; all superintendents of quarantine stations, inspectors, assistant inspectors, veterinary inspectors, microscopists, assistant microscopists, meat taggers, stock examiners, and live-stock agents in the Bureau of Animal Industry; all professors, forecast officials, local forecasters, observers, and all other officers and clerks in the Weather Bureau; all compositors, pressmen, folders, engineers, assistant engineers, firemen, messengers, assistant messengers, and watchmen; but no messenger, watchman, or other subordinate can be promoted to the grade of clerk except after passing an examination.

The only persons not in the classified service in the Department of Agriculture are the Secretary, Assistant Secretary, and Chief of the Weather Bureau. Those officers are appointed by the President of the United States. The private secretary to the Secretary of Agriculture is the only person excepted from examination by the civil-service rules. The remaining 556 persons on the rolls of the Department November 1, 1896, were laborers, workmen, charwomen, and others in a subordinate grade. A great proportion of these 556 are rainfall and river observers in the Weather Bureau, at salaries ranging from $3 to $25 per month, and their employment is intermittent. Every person ranking as a skilled laborer and skilled workman is now included in the classified service in this Department.

NEW APPOINTMENTS.

There have been three scientific divisions established during the last four years. In that time seven vacancies have occurred by death and resignations among the chiefs of scientific divisions. How were these important positions filled? Notwithstanding the fact that none of these positions was at that time included in the classified service, those in the new divisions were filled by the appointment of skilled scientists who had served the Department under previous administrations. Five other vacancies were filled by promoting men in the same divisions. Only two were appointed from the outside.

The President of the United States has made two appointments in the Department of Agriculture since 1893. The first was that of Assistant Secretary. The gentleman chosen for that position, Dr. Charles W. Dabney, jr., is a graduate in agricultural chemistry, and had been ten years director of agricultural experiment stations in this country and eight years president of the University of the State of Tennessee. He never sought the position. The position, however, sought him with great vigor, and at last he was persuaded to accept the same, and the manner in which he has efficiently discharged all the duties thereunto appertaining has given great satisfaction to the country.

The present Chief of the Weather Bureau was appointed after an examination for promotion to a professorship in the Weather Bureau, and after that was called to his present position. He had served twenty years as a Weather Bureau observer, and was promoted to the professorship after a very severe competitive examination, followed by a practical test of skill in forecasting the weather, held under the supervision of a board made up of Professors Mendenhall and Harrington, Maj. H. H. C. Dunwoody, of the United States Army, and the Assistant Secretary of Agriculture.

After a service of about eighteen months the improvement in the forecasts of the Weather Bureau as to accuracy and utility demonstrates that the present chief is a very useful and efficient officer.

A thorough canvass of the Department shows that about 1,000 persons out of the total of 2,217 employed are engaged upon purely technical or scientific work. An analysis of the last appropriation act shows that out of the $2,448,532 appropriated for the Department of Agriculture, over $1,700,000, or about 70 per cent, was appropriated for scientific or technical as distinguished from the administrative or general work.

DIRECTOR OF SCIENTIFIC WORK.

There is one more step to be taken to complete the already nearly perfect system of civil service in this Department. Every chief of a bureau or division, except the Chief of the Weather Bureau, is now in the classified service. The Secretary and Assistant Secretary are appointed by the President. They therefore change with every incoming Administration. There is, consequently, every four years a period of time when the Department is left without a single administrative officer to hold this vast and useful system together. But there should be such an officer. Therefore, in this connection attention is called to the communication sent to the Senate and House Committees on Agriculture, dated February 15, 1896, in which it is urged upon the legislative branch of the Government as a simple business proposition, needing no argument to support it, that this vastly important and comprehensive work, promoting, as it does, the development of almost every resource of our land and every industry of our people, our production at home and our markets abroad, and concerning even the food and health of a large part of our population, for which $1,750,000 is annually expended, and in which nearly a thousand scientific and technical experts are engaged, should have a permanent, broadly educated, and experienced scientific superintendent.

No permanent and adequate direction and supervision is provided in the present organization of the Department. It is not to be supposed that the Secretary of Agriculture, a member of the President's Cabinet, even if a farmer and an experienced executive, will necessarily be a technically trained scientific man. Even if he should be, he occupies the position only four years, and thus scarcely becomes familiar with the difficult and complex work of the Department before he leaves it. The Assistant Secretary of Agriculture is subject to the same conditions. Because he must represent the Secretary in the Administration, he must go with the Administration. These conditions, which are necessary and inherent in our system of government, it is not proposed to change. A Secretary and Assistant Secretary are both needed. But another permanent officer is needed to direct the work of the various scientific bureaus of the Department, under the general authority of the Secretary, and to give permanence to the policy of the Department.

NECESSITY OF SETTLED POLICY FOR SCIENTIFIC WORK.

In order to accomplish the best and most permanent results, this Department must have a settled policy with regard to all its scientific work. This Department has less relation to the general executive business of the Government, and less connection with what is usually called politics, than any other Department of the Government. In fact, the scientific work of the great bureaus, divisions, and surveys, above referred to, should be kept free from politics to be efficient and impartial to the interests of all. The numerous bureaus and divisions do not have under the present organization, in fact can not have, the attention and direction which the interests involved demand. After a change of Administration the Department is practically headless, and to a great extent helpless, until the new Secretaries have had time to master the details of the technical work. Such a director of scientific divisions is needed therefore, if for nothing else, to carry on the scientific work of the Department from one Administration to the next. Is it conceivable that any great manufacturing, railroad, or mining company, undertaking such difficult scientific work, and using so much money and so many men, would provide for it no permanent scientific direction or supervision whatever, and then change all the heads every four years, leaving the work practically at a standstill, or, which is worse, entirely without direction or supervision, for six months to a year? The change of Administration affects the work of this Department even more than it does that of others, because its work is less of a routine character, is more progressive, changes more frequently, and thus requires constant direction to keep it usefully going. The bureaus and divisions of this Department can not do practically the same thing year after year, as they do in the great business Departments of the Government, but must, if they serve the people properly, do a new and different thing almost every month in the year. They therefore need constant assistance and supervision much more than do the divisions of other Departments.

NEED OF AN ADDITIONAL EXECUTIVE OFFICER.

Aside from these special considerations with regard to the scientific work, the Department of Agriculture greatly needs another general executive officer. It has only two Secretaries authorized to take official action. There is no provision in the laws for any officer of the Department to act in case of the absence of the two Secretaries, as there is in some of the other Departments. Either the Secretary or the Assistant Secretary has to be present in the Department every day and every official hour during the year.

The bureaus and divisions in Washington are, contrary to the popular idea, much the smaller part of the Department of Agriculture. Outside of Washington there are 154 observing stations and 52 signal stations of the Weather Bureau. There are 152 meat-inspection

stations in 40 different cities and towns in the country; 21 different quarantine stations for import cattle at points on the coast, the Canadian and Mexican boundary; 9 different stations for inspecting export stock, and 19 for inspecting stock for Texas fever, making a total of nearly 200 stations in the Bureau of Animal Industry, which should have inspection and supervision occasionally by the highest authority of the Department. The agricultural experiment stations, located in different States and Territories, and several experiment stations of the Department of Agriculture must be inspected by this Department. In addition to these, the Department has many other agencies for studying soils, foods, and food dietaries, testing timbers, and collecting material illustrating our natural resources, scattered all over the country. The Secretaries or Director should be in position to visit and examine the work of the various agencies for the purpose of informing themselves as to their uses and needs. In view of the great amount of business done, and of the large number of branches of the Department scattered all over the country, another executive officer is greatly needed in order to permit a better distribution of work and a more regular and thorough supervision of the outlying branches of the Department. The new officer here asked for should therefore be authorized to act, when called upon by the Secretary, as a Second Assistant Secretary.

The salary attached to the position should be sufficient to secure the services of a broadly educated scientific man, who has had the necessary experience in the administration of affairs and the direction of scientific work, and should be equal to that paid for similar services in other branches of the Government.

These considerations were duly presented to the Senate Committee on Agriculture and Forestry, and the subject was held under advisement some time, with the result that Senate bill 3131, providing for carrying the suggestions into practical effect, was introduced, but it was too late for consideration during the last session of Congress. The report of the Senate committee recommending the passage of the bill was accompanied by the testimony of several distinguished scientific gentlemen who had appeared before the committee. It was also advocated in a great number of letters and memorials from institutions of learning and scientific men throughout the country. In view of the evident unanimity of the scientific world in favor of the establishment of the office of "Director in Charge of Scientific Bureaus and Investigations" for the Department of Agriculture, the estimates for the next fiscal year contain a recommendation for an appropriation for the salary of $6,000 per annum, to be paid to whomever may be selected for this position.

INADEQUACY OF SALARIES OF HIGHER OFFICIALS.

It is well to here reiterate the statement made in the report of the Secretary of Agriculture for 1895, that the salaries paid in this Department for ordinary clerical work are out of proportion to those paid

scientific experts who render the highest type of intellectual service. The chiefs of scientific bureaus and divisions and their skilled assistants do the actual thinking and reasoning for the development and elevation of agricultural science. These persons are not adequately compensated. Practical, scientific investigation of agricultural problems is the primary function of this Department. The best ability and attainments can only be enlisted by the offer of sufficient salaries. And, in addition to compensation, laboratories, equipments, libraries, and clerical assistance must be generously furnished, in order to retain the highest character of skill and experience.

The scientific organization of this Department has been formulated during the last six or eight years. The average age of chiefs of scientific bureaus and divisions is 42 years and 3 months. The youngest chief is 29 years and the oldest 51 years of age. Among these heads of scientific divisions and bureaus the longest term of service is 13½ years. The average age of assistant chiefs is 31 years and 4 months, the youngest being 28 and the oldest 35 years of age. The assistant chief longest in the service has been in the Department 5 years and 3 months. The average duration of service of the assistants is only 2 years and 4 months.

The foregoing shows that the Department of Agriculture is very generally officered by young men. This is suggested, not as a disadvantage at the present time, but because it is proved by the experience of the past few years that these young gentlemen can not be retained by the Department at the present rate of compensation.

The salary of a chief is now $2,500, and that of an assistant $1,800. These salaries are not adequate. It has therefore been recommended in the estimates for the next fiscal year that the salaries of chiefs of divisions be increased to $3,000, and those of assistant chiefs to $2,000. This recommendation is submitted in the interests of equity and in order to put chiefs of the Department upon an equality with scientific experts employed in other branches of the Government service. In the Coast Survey salaries of the principal scientific assistants range from $3,000 to $4,000. Geologists and chiefs of scientific divisions in the Geological Survey receive from $2,700 to $4,000. In this Department there is also precedent in the salaries paid professors of meteorology in the Weather Bureau and in the compensation of Director of the Office of Experiment Stations, already fixed at $3,000 per annum. These salaries may be fairly compared with those paid scientific professors in the universities, colleges, and other institutions of learning in the United States. Inquiry shows that the salaries of heads of scientific departments in universities and colleges in the Eastern States range from $3,000 to $5,000, while in those institutions in the great populational centers, where the cost of living is enhanced, far larger sums are paid per annum.

Salaries paid directors of experiment stations in the various States

show that these officials are paid in the Eastern and Middle States an average salary of $2,930. The same officers in the South Atlantic States average $2,800 per annum. In the Central Western States they are paid $2,550, and in the Rocky Mountain and Pacific States a little more than $3,100, and living expenses in all of the localities referred to are probably much lower than in Washington.

VALUABLE SERVICES LOST TO THE DEPARTMENT.

On account of the low salaries paid for scientific and skilled services, the Department is constantly losing some of its ablest and best workers. The universities, colleges, and experiment stations, paying better salaries and offering equal opportunities for useful work and the acquirement of national reputation, are frequently taking the best men. Thirty-two leading scientific experts have left the Department during the last few years to take positions in other institutions, at a rate of remuneration averaging fully 50 per cent more than they received from the Government of the United States. Quite a number of scientists who received under the Government from $1,000 to $1,200 per annum only have gone to the service of colleges, universities, and private institutions of learning and corporations at salaries ranging from $2,000 to $3,000 per annum, with possibilities of still greater compensation.

It is evident from the foregoing that the Department can not retain its needed share of learned and experienced experts unless it pays salaries equal to those given for similar services in the educational and commercial corporations of the country.

INSPECTION OF ANIMALS INTENDED FOR FOOD.

The Bureau of Animal Industry must continue to increase the number of its force in all of the great cattle and swine centers of the United States, if efficiency is attained and maintained. The ante-mortem and post-mortem inspection of animals intended for food involves great labor and skill. The inspectors and assistant inspectors, whose duty it is to look after and report upon these cases, are in the classified civil service. No man can be examined by the United States Civil Service Commission for either inspector or assistant inspector who does not—as a condition precedent to such an examination—first exhibit his diploma from some reputable veterinary college.

Of the fifty-one (51) in the performance of this particular character of inspection in the year 1895, fourteen (14) only had passed the examination, while of the seventy-seven (77) now employed, forty-six (46) have been taken from the eligible list of the Civil Service Commission. This shows the steady growth of a legitimate and purely nonpartisan service in this important Bureau.

Table showing total number of employees engaged in meat inspection only on the 30th of June of each year and the number of these who were appointed upon certification by the Civil Service Commission.

Year.	Inspectors and assistant inspectors.		Stock examiners and taggers.		Clerks.		Microscopists.	Assistant microscopists.	Laborers.	Total.
	Total.	Civil-service appointments.	Total.	Civil-service appointments.	Total.	Civil-service appointments.				
1892	33	----------	151	----------	11	----------	7	143	30	375
1893	32	----------	163	----------	6	----------	9	177	31	418
1894	40	----------	199	----------	6	----------	7	171	16	439
1895	51	14	232	----------	12	----------	5	195	32	527
1896	77	46	287	76	17	4	4	183	11	579

INCREASED EFFICIENCY DUE TO CIVIL SERVICE.

The effect of placing the force of the Bureau of Animal Industry within the classified service has been very marked in increasing its efficiency and improving its discipline. This is particularly apparent with the employees stationed at other cities than Washington. The decreased expense of the inspection work is largely due to this improvement in the force. Every person feels now that his standing, retention in the service, and chance of promotion depend upon the interest which he shows and the care and fidelity with which his duties are efficiently performed.

On March 4, 1893, there were seven hundred and eighty-one (781) persons employed by this Bureau, but on November 1, 1896, there are only seven hundred and fifty-eight (758), notwithstanding the fact that the work has more than trebled.

Since March 4, 1893, one hundred and fifty-eight (158) persons have been placed in this Bureau from the eligible lists of the United States Civil Service Commission.

These facts demonstrate to the consumers of the meat products of the United States at home and abroad that there is a scientific and careful inspection made of all meats intended for interstate and foreign commerce. The sanitary value of the system is beyond computation. It protects health and life. Inspection will become so general and so perfect that not a single pound of unwholesome meat will find its way from the United States to foreign markets, nor will any be sold at home which does not carry certification of inspection. State and municipal authorities are becoming more alert in cooperating with the United States authorities in their attempt to prevent the sale in great cattle and swine slaughtering cities of the animals, carcasses, and meats which the inspectors of the Bureau of Animal Industry have rejected and thrown out of interstate and foreign trade.

ANTE-MORTEM INSPECTION OF ANIMALS AT ABATTOIRS AND STOCK YARDS.

Following is a statement of the ante-mortem work at the abattoirs and stock yards. The figures in the first column approximate the actual number of animals inspected for abattoirs having Government inspection, and include those inspected in the yards for such local abattoirs and those inspected at the abattoirs in cities where there is no yard inspection. The second column gives the additional number of inspections in the yards on animals not purchased for the official abattoirs in those cities, and does not represent the actual number inspected, for the reason that as the inspection is made at the scales and the animals may change hands several times, being weighed on each occasion, the same animal may pass the inspector more than once. The number of animals rejected as unfit for food may be ascertained by adding the number condemned at the abattoirs, both ante-mortem and post-mortem, and the number condemned post-mortem in the stock-yards inspection.

Ante-mortem inspection.

Animals.	Number of inspections.			Animals condemned.		
	For official abattoirs in cities where the inspection was made.	For abattoirs in other cities and miscellaneous buyers.	Total.	At abattoirs.	In stock yards.	Total.
Cattle	4,050,011	3,479,512	7,529,523	233	22,123	22,356
Sheep	4,710,190	1,608,094	6,318,284	692	12,533	13,225
Calves	213,575	101,271	314,846	47	2,790	2,837
Hogs	14,301,963	7,452,863	21,754,826	11,889	39,092	50,981
Total	23,275,739	12,641,740	35,917,479	12,861	76,538	89,399

Last year the number of animals inspected for abattoirs having official inspection was 18,783,000, and the total number of ante-mortem inspections made was 23,885,721. There has been an increase in the past year, therefore, in the number of animals inspected for abattoirs where inspection was maintained of 4,492,739, or nearly 24 per cent, which is due principally to the extension of the inspection to sheep, which had not before been possible. The increase in the total number of inspections is 12,031,758, or over 50 per cent.

POST-MORTEM INSPECTION OF ANIMALS.

Following is a table showing the number of animals inspected at time of slaughter and number of carcasses and parts condemned:

Post-mortem inspection.

Animals.	Number of inspections.			Carcasses condemned.			Parts of carcasses condemned at abattoirs
	At abattoirs.	On animals condemned in stock yards.	Total.	At abattoirs.	Stock-yards inspection.	Total.	
Cattle	3,985,484	9,977	3,995,461	4,886	3,871	8,757	6,798
Sheep	4,629,796	3,546	4,633,342	2,794	1,541	4,335	212
Calves	256,905	931	257,836	276	761	1,037	33
Hogs	14,250,191	28,028	14,278,219	31,178	15,011	46,189	33,960
Total	23,122,376	42,482	23,164,858	39,134	21,184	60,318	41,003

Last year the number of post-mortem inspections reported was 18,883,275.

There were 13,289,680 quarters and pieces of beef, 328,589 carcasses of hogs, 151,959 sacks of pork, 3,516,896 carcasses of sheep, and 183,685 carcasses of calves tagged or otherwise marked as inspected meat. Of these there were exported 1,030,334 quarters and 16,818 smaller pieces of beef (equivalent to nearly 260,000 cattle), 349 carcasses of sheep, and 3,281 carcasses of hogs.

The meat-inspection stamp was affixed to 3,697,701 packages of beef and 6,034,165 packages of hog products; 63,313 of the latter contained microscopically examined pork. There were issued 15,211 certificates of inspection for meat products, of which 3,481 were for microscopically examined pork.

There were sealed 11,855 cars containing inspected meat in bulk for shipment to establishments having Government inspection and to other places.

COST OF INSPECTION, TAGGING, ETC.

The cost of this work was $341,456.25, or 0.95 cent for each ante-mortem inspection, and covers the expense of all subsequent work of post-mortem inspection, tagging, stamping, and issuance of certificates of inspection. In 1895 it was 1.1 cents, in 1894 it was 1¾ cents, and in 1893 it was 4¾ cents.

Table showing number of abattoirs and cities where inspection was maintained during the fiscal years given.

Fiscal year.	Number of abattoirs.	Number of cities.
1892	23	12
1893	37	16
1894	46	17
1895	55	19
1896	102	26

MICROSCOPIC INSPECTION OF PORK—COST.

The following table shows the exports of microscopically inspected pork, 1892–1896:

Fiscal year.	To countries requiring inspection.	To countries not requiring inspection.	Total.
	Pounds.	*Pounds.*	*Pounds.*
1892	22,025,698	16,127,176	38,152,874
1893	8,059,758	12,617,652	20,677,410
1894	18,845,119	16,592,818	35,437,937
1895	39,355,230	5,739,368	45,094,598
1896	21,497,321	1,403,559	22,900,880

The exports for 1895 were unusually heavy, but if we compare 1896 with other years it will be seen that this year's shipments to countries requiring the inspection were greater than in 1893 and 1894. The shipment of microscopically inspected pork to countries not requiring this inspection has been intentionally discouraged upon grounds of economy.

There were 469,025 carcasses and 510,355 pieces examined, making a total of 979,380 specimens inspected by the microscopical force. Eleven thousand one hundred samples contained trichinæ.

The cost of this inspection was $60,485.93, an average cost per specimen of 6.18 cents.

Last year the number of specimens examined was 1,910,415 (almost double the number this year), and consequently the average cost was less, being 4.9 cents; in 1894 it was 6⅗ cents, and in 1893 it was 8¾ cents.

The cost of the microscopical inspection per pound of inspected meat exported was 0.264 cent; in 1895 it was 0.2 cent, and in 1894 0.248 cent.

NOTE.—The cost per pound, as given above, was obtained, as heretofore, by dividing the cost of the work during the year by the number of pounds exported. This method is objectionable, because the true average cost per pound can not be found by it, for the reason that the meat examined during one month may not be exported for several months. To illustrate this point: During the first six months the cost was $19,848.92; pounds exported, 10,492,180; last six months, cost, $40,637.01; pounds exported, 12,408,700, making an average of 0.19 cent for the first period and 0.33 cent for the last. From this it would seem that the meat examined during the latter part of the fiscal year was intended for shipment during the next year.

INSPECTION OF VESSELS AND EXPORT ANIMALS.

There were during the year 819 clearances of vessels carrying cattle and sheep. All of these vessels were carefully inspected as to fittings, space, and other accommodations for live stock before a clearance would be authorized. The number of certificates of inspection of export animals issued was 1,393.

Below is a statement showing the inspection of domestic cattle and sheep for export and the number exported for 1896 and previous years:

Fiscal year.	Cattle.				Sheep.		
	Number of inspections.	Number rejected.	Number tagged.	Number exported.	Number of inspections.	Number rejected.	Number exported.
1896	815,882	1,303	377,639	365,345	733,657	893	422,003
1895	657,756	1,060	324,339	324,299	704,044	179	350,808
1894	725,243	184	360,580	363,535	135,780		85,809
1893	611,542	292	280,570	289,240			

During the year the number of Canadian cattle exported from American ports was 1,482; number of Canadian sheep, 10,512. Last year there were 1,834 cattle and 38,873 sheep from Canada.

The percentage of loss in the shipments of cattle and sheep to London, Liverpool, and Glasgow, where inspectors of this Department are stationed, is about half that of last year. The number of cattle inspected after landing was 348,833; the number lost in transit was 1,107, or 0.32 per cent, against 0.62 per cent last year and 0.37 per cent in 1894. The number of sheep inspected was 389,534, and 4,587 were lost on the voyage, a percentage of 1.16, compared to 2.7 in 1895 and 1.29 in 1894.

The cost of the export inspection and the Texas-fever work, which includes the inspection of live stock imported from Mexico, was $107,273.07. Taking half of this sum as the amount chargeable against the inspection of animals for export, the cost of inspecting the 787,948 cattle and sheep exported would be $53,636.54, or 6.8 cents per head. Last year the average was 7.74 cents, and in 1894 it was 10.75 cents per head. The number of individual inspections made on these animals was 1,549,539 in this country and 738,367 in Great Britain, a total of 2,287,906. This gives an average cost of 2.34 cents for each inspection, against 2.66 last year.

SOUTHERN CATTLE INSPECTION.

During the quarantine season, from February 15 to December 1, 1895, 47,082 cars, containing 1,224,715 cattle, from the infected district were received and inspected at the quarantine pens in the various stock yards, and 45,390 cars were cleaned and disinfected under supervision of the inspectors.

Orders issued by the Secretary of Agriculture modifying the regulations governing the importation of live stock admitted cattle from Mexico, after inspection, for immediate slaughter or for grazing below the quarantine line, subject to the regulations applying to the native cattle of the infected district. Under these orders there were 219,814 Mexican cattle imported and inspected during the year.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS.

The number of animals imported and quarantined during the year was as follows:

Quarantine station.	Cattle.	Sheep.	Swine.
St. Denis, Md	----------	45	----------
Garfield, N. J	54	265	22
Littleton, Mass	----------	7	
Vanceboro, Me	1	----------	----------
Newport, Vt	10	----------	----------
Buffalo, N. Y	380	----------	----------
Port Huron, Mich	10	----------	----------
Total	455	317	30

There were also at the Garfield station 12 camels, 1 goat, and 1 deer, making a total of 816 imported animals held in quarantine for the prescribed period.

The number of animals imported from Canada and inspected not subject to quarantine was 317,038 sheep, 216 swine, 151 cattle, and 2 deer. There were also inspected 2,168 sheep, 42 hogs, and 3 goats imported from Mexico.

For the purpose of comparison the following table is given:

Table showing the number of animals inspected for abattoirs having inspection.

Fiscal year.	Cattle.	Calves.	Sheep.	Hogs.	Total.
1891	83,891				83,891
1892	3,167,009	59,089	583,361		3,809,459
1893	3,922,174	92,947	870,512		4,885,633
1894	3,862,111	96,331	1,020,764	7,964,850	12,944,056
1895	3,752,111	109,941	1,344,031	13,576,917	18,783,000
1896	4,050,011	213,575	4,710,190	14,301,963	23,275,739

PRODUCER SHOULD PAY COST OF INSPECTION.

In the interests of public health there should be Government inspection of all animals intended for human food and of all meat products prepared for consumption in the United States and abroad. The protection of the health of its citizens is an unquestioned function of Government. But when the assurance of such protection is given by a Government certificate to be placed upon the product of any slaughterhouse or butchering establishment, it enhances the value of that product by creating a demand for it which uninspected meat does not enjoy. Therefore the Government certificate of inspection declaring any meat or other food wholesome and edible enhances its value over that which is not certificated. For this enhancement, which the producer charges up to the consumer, the producer ought to pay.

It is not the duty of the Government to maintain the Bureau of Animal Industry at great expense to all the people in a manner to give direct pecuniary benefits to only the few who produce and prepare meats for market. For this reason it is urged that the law relative to meat inspection should be so amended as to have the work carried on carefully and efficiently by the agents of the Bureau of Animal Industry, and the cost of inspection assessed against all those whose meats and other animal products are inspected and stamped as wholesome. It is generally admitted that the market price of inspected meats runs from one-eighth of a cent to 1 cent per pound higher than that of meat of apparently the same quality which has not been inspected and certificated. This proves the value in public estimation of governmental supervision and inspection, and as the consumer gladly pays the enhanced price it is only fair that the producer should pay for the work which caused that price. The moment

the Government demands pay for its services from those to whom they are rendered meat inspection will become universal at the great slaughtering centers of the United States.

Many of the larger proprietors and packers have signified their willingness to have their animals, meats, and meat products rigidly inspected and passed upon by Government agents at their own expense.. They wisely say: "The consumer will pay for it at last."

From the foregoing it is reasonable to conclude that a properly drafted statute might make the Bureau of Animal Industry not only self-sustaining, but also a legitimate source of internal revenue, without doing injustice to either producers or consumers and without putting any appreciable burden upon either.

THE CATTLE AND MEAT TRADE OF GREAT BRITAIN.

The people of Great Britain consume annually about 109 pounds of meat for each person, and 75 per cent of that meat is produced in the United Kingdom. The remaining 25 per cent of the meat food of the United Kingdom is imported. During the fiscal year 1896, 120,000 tons of live animals have been taken into the United Kingdom. In addition to that, there were imported 110,000 tons of fresh meat, either chilled or frozen. Besides the latter, 43,000 tons of salted meat were received by the English. During the same period of time the home product of meat was 827,000 tons. Thus the total consumption for the year in the United Kingdom was 1,100,000 tons.

There is a constant increase of the live-stock trade with Great Britain. The English prefer the live animals rather than their carcasses. The reason for this is found in the freight charges. Ships which have been fitted up for cattle, swine, and other animals can return with merchandise of all sorts for freights; but the refrigerated ships—those which take chilled and frozen beef to Europe—are not adjustable for other freights on the return voyage and have therefore to come home in ballast. The consequence is that the advantage of a lesser freight for chilled and frozen meat than for live cattle is more than overcome by the fact that there is frequently no opportunity for paying return cargoes.

In addition to that, there is an insurmountable prejudice on the part of the British consumer against carcasses slaughtered in other countries and shipped to England as chilled or frozen meats. The Englishman prefers to see the animal alive and to have it slaughtered in England.

The United Kingdom imported during the last year 31,000 tons of live mutton. During the same period frozen or chilled sheep carcasses were taken amounting to 119,000 tons, salted mutton 24,000 tons, while there were produced 356,000 tons of mutton within the United Kingdom, making a total production and consumption during the year in Great Britain of 530,000 tons.

It will be observed that frozen-mutton shipments are far larger in proportion to the live-sheep shipments than the live-cattle are to the chilled-beef shipments. Nevertheless there is a distinct tendency toward increasing shipments of live sheep, notwithstanding the great distances of the chief centers of supply from the English market.

The live meat arriving in the United Kingdom during the first six months of the year 1896 was supplied as follows: By the United States, 75.10 per cent of the cattle and 45.26 per cent of the sheep; Canada, 9.10 per cent of the cattle and 3.27 per cent of the sheep; Argentina, 15.50 per cent of the cattle and 50.60 per cent of the sheep; while all other countries furnished 0.30 per cent of the cattle and 0.87 per cent of the sheep.

During the same period of time, ending June 30, 1896, dead meat was supplied to the United Kingdom in the following proportions: The United States supplied 81.30 per cent of the beef and other countries 18.70 per cent. Germany supplied 0.22 per cent of the mutton; Holland, 4.20 per cent; Argentina, 26.53 per cent; Australasia, 69 per cent, and other countries, 0.05 per cent.

SHEEP AND CATTLE FROM ARGENTINA.

Argentina, it will be noticed by the table of live animals, shipped a larger proportion of sheep than the United States, and at the same time the Argentine shipment of cattle exceeds that of Canada. It is a thirty days' voyage from Argentina to British ports. There is, therefore, a considerable waste in weight, much loss of animals by death, and enhanced freight charges, but the British public demands live animals, and this demand overcomes the increased cost of freight and the consequent enhanced price to the consumer, which is willingly paid. A mutton carcass killed in England brings about $4 more than the same quality of mutton which has been killed abroad and is taken into that market frozen. Shipments of live sheep from Argentina have been very satisfactory to English consumers.

Cattle from Argentina are inferior to those from the United States. They are not as large, well graded, or as well fattened. There is, however, a constant improvement in Argentinian herds, because they are steadily introducing the best thoroughbred bulls from England, France, and the United States. The breeds most sought for by Argentinian cattlemen are the French Durhams, English Shorthorns, the Hereford, and Scotch Aberdeen Angus. And while the stock growers of Argentina are thus improving their cattle they are not unmindful of their sheep flocks, but are constantly introducing among them Romney Marsh, Leicester, Oxford Downs, Shropshire, and Lincoln rams.

WHOLESALE PRICES OF DRESSED MEATS IN LONDON.

The following table (p. 26) shows the average wholesale prices of dressed meats at the London Central Meat Market during the years 1895 and 1896, per 100 pounds.

Average wholesale prices of dressed meats at the London Central Meat Market, 1895–96.

[Per 100 pounds.]

Product.	First quarter, 1896.	Second quarter, 1896.	Third quarter, 1896.	Year 1895.
	Dollars.	*Dollars.*	*Dollars.*	*Dollars.*
Beef:				
Scotch short sides	11.50 to 12.37½	12.12 to 13.12	12.12 to 13.50	12.87½ to 13.62½
Scotch long sides	10.50 to 11.25	10.75 to 11.25	11.37½ to 12.25	11.50 to 12.12½
English prime	10.50 to 11.25	10.50 to 11.00	10.50 to 11.25	11.25 to 12.12½
Cows and bulls	5.00 to 8.00	5.00 to 8.00	5.25 to 7.50	6.75 to 9.25
American—				
Birkenhead killed	8.50 to 9.25	8.25 to 9.25	8.50 to 10.25	10.00 to 10.75
Deptford killed	8.50 to 9.50	8.00 to 9.50	8.50 to 9.50	10.00 to 11.00
Refrigerated hind quarters	9.00 to 10.00	9.50 to 10.50	10.00 to 11.00	10.75 to 12.12½
Refrigerated fore quarters	5.75 to 6.25	5.00 to 6.00	4.75 to 5.50	6.50 to 7.50
Argentina	6.50 to 8.25	6.50 to 8.00	6.00 to 7.00	8.75 to 10.25
Australian—				
Frozen hind quarters	4.75 to 5.25	5.25 to 5.75	5.50 to 6.50	6.50 to 7.00
Frozen fore quarters	4.00 to 4.25	3.50 to 4.00	3.00 to 3.25	4.75 to 5.00
Mutton:				
Scotch prime	12.12½ to 12.37½	12.37½ to 14.00	12.12½ to 14.62½	14.37½ to 15.37½
English prime	11.50 to 13.12½	11.75 to 13.37½	11.00 to 13.37½	13.37½ to 14.62
Ewes	8.25 to 10.00	8.25 to 10.25	10.00 to 10.25	10.25 to 11.50
German	10.25 to 11.25	11.75 to 12.50		12.12½ to 13.12½
New Zealand frozen	6.25 to 7.75	5.50 to 6.75	6.00 to 7.25	7.90 to 7.75
Australian frozen	4.50 to 5.00	4.25 to 4.50	5.00 to 5.75	5.50 to 6.00
River Plate frozen	4.25 to 5.00	4.25 to 5.00	5.25 to 5.75	5.50 to 6.00
Lamb:				
English	18.25 to 22.00	16.50 to 19.50	14.00 to 16.50	16.62½ to 19.25
New Zealand frozen	10.50 to 12.37½	8.75 to 10.00	9.00 to 9.50	8.50 to 10.00
Veal:				
English	14.00 to 16.00	11.25 to 13.75	10.75 to 13.25	12.37½ to 14.25
Pork:				
English small	9.00 to 10.00	9.00 to 10.75	8.25 to 9.25	10.00 to 11.00
English medium, large, and foreign	7.00 to 8.75	7.00 to 8.50	7.00 to 7.75	8.00 to 9.50

THE HANDLING OF FROZEN MEATS.

Each year there is visible improvement in the methods of defrosting meats in European markets. Frozen mutton from the antipodes and from Argentina reaches the retail butcher shop in better form and appearance than formerly. This great industry has been developed under adverse conditions to shippers, because of their inability to obtain fairly remunerative prices. First-class English butchers will not handle frozen meat at all in some of the larger cities. It is, therefore, relegated to small shops in cheap neighborhoods where low prices obtain. All efforts upon the part of shippers and sellers have failed to break down English prejudice against such meats. They do not, therefore, in the form of frozen mutton or frozen beef seriously compete with the live shipments of cattle from the United States. But they do really compete with cheese, bacon, and pork.

LIVE-SHEEP SHIPMENTS.

The growth of the live-sheep shipments is interesting. The United Kingdom took during the year 1893, 62,682; in 1894, 484,597; in 1895, 1,065,470, and during the first nine months of the year 1896, 614,855 head. This slight falling off for the present year is owing to the compulsory slaughtering on landing and consequent impossibility of fattening the sheep on English pastures. In previous years foreign sheep were pastured in Great Britain, and, after being fitted for market, sold at top prices as English.

The enormous imports of beef and mutton to the United Kingdom are an absolute necessity. Domestic production lacks that much of supplying the demand. The utmost capability of meat production has probably been reached in the United Kingdom, but the population continues to augment and the per capita consumption of meat increases with each year. Nevertheless, the imported animals and meats are looked upon with suspicion by the Government, with jealousy by the farmers, and with mistrust by some of the consumers.

From January 1 to September 30, 1896, Great Britain received a greater number of cattle than ever before taken in during a period of nine months. It even exceeded the number taken in during the same period of the year 1894.

The business of supplying the English market with meats is full of risks and vicissitudes, and therefore requires large capital. This whole trade is concentrated at present in a very few hands. The number of shippers from the United States may be counted upon one's fingers. During the first eight months of the year 1896 the business has been unsatisfactory and only barely remunerative. Prices have advanced considerably with the progress of the year, especially for top cattle of prime quality.

Cattle were sent from the United States to Liverpool during the early autumn at $6.08 a head freight. Charges from the River Plate were $25.55 a head in the early part of the present year, but were reduced to $15.81, and even to as low a figure as $14.60, during the present autumn. Lowering rates stimulated shipments. Great Britain furnishes, as a rule, between the months of May and September enough native stock to lower prices of American and other imported cattle.

Among the parliamentary enactments of 1896 was a bill for compelling the slaughter of all animals at the point of debarkation. This act, however, made no change in practice, as, under departmental orders, such slaughtering had been carried on for some years.

QUALITY OF COMPETING CATTLE PRODUCTS.

Cattle from the United States have for a long time been arriving at English ports in such perfect condition that there is neither need nor desire to further fatten them before killing. It is not the same with

Canadian cattle. Evidence from agents of the United States Department of Agriculture from Birkenhead, from Glasgow, and from Bristol is concurrent to the effect that the quality of animals from the United States is far superior to that of those received from Canada. At all the points named Canadian cattle have been found short in weight and poor in quality. The same fault is found with animals from South America. Corn-fed animals from the United States have, however, proved very superior and achieved some notable triumphs during the year. About one-third of the South American cattle shipped to London and Liverpool in 1896 from the River Plate were sold at from 5 cents to 6 cents per pound.

These were mostly wild pampas cattle, which suffer very much on the voyage over the ocean, and do not begin to feed until half the distance to Liverpool is covered. Nevertheless there are quite a number of River Plate cattle bred specially for British markets, and pastured and afterwards stall fed after the American method, and these are said to compare favorably with the cattle from the United States as to weight and quality. South America has shipped animals of such inferior quality at times as to have made great loss, and it is clearly proven that it pays to ship only the very best grades and quality of beef cattle to the United Kingdom.

The present prospect for good prices for American beef in the English market is not encouraging. Supplies are abundant and low freights prevalent. Under these circumstances only moderate profits may be hoped for in the future, even if the English market retains a healthy tone and steady demand.

The exclusion of United States and all other foreign cattle from the Continent forces practically all of the surplus of the United States into Great Britain and tends to keep prices down for the English consumer.

During the last twelve months American cattle have uniformly arrived on the other side in good health and condition. Only forty or fifty head were condemned at Glasgow as suffering from Texas fever. It would perhaps be of advantage to American shippers to especially study the Glasgow market. In that city cattle from the United States compete with the very highest quality of British animals. During the year 1896 it has been admitted that American cattle have been the best of all those landed at that port. They arrived in good condition in winter as well as in summer, and their quality is admittedly very superior. The Glasgow people seem to have a preference for animals shipped from Baltimore, which are mostly Shorthorn crosses, though in the autumn quite a large number of Polled Angus cattle arrive there. Light-weight, smooth-finished steers during the warm months of summer will pay the shipper the best profits in the Glasgow market. It has been shown to the Department that the highest prices and the highest praises have been bestowed upon beef from the United States

in the Glasgow markets during the year 1896, but it must be admitted that those meats were sold as "prime Scotch" or "English" joints.

Prices of many American cattle are lowered because of the deep branding on their hides. It has been estimated that 10 per cent has been deducted from the value of some animals because of the branding upon them.

MEAT IMPORTED BY GREAT BRITAIN.

The meat producers and packers of the United States can learn from the following tables the quantity of meat taken into the United Kingdom of Great Britain, and also the sum total of the aggregate which has gone from this country during the last four years and the three first quarters of the year 1896:

Quantity of meat imported into the United Kingdom during the four years 1892–1895, and nine months of 1896.

[Figures given are for thousands, three ciphers (000) being omitted.]

Meat product.	1892.	1893.	1894.	1895.	1896 (9 mos.).
Bacon:	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
From United States	2,896	2,177	2,562	2,649	2,070
From other countries	985	1,022	1,128	1,414	1,353
Total	3,881	3,199	3,690	4,063	3,423
Beef:					
Salted—					
From United States	267	188	235	212	180
From other countries	8	13	7	8	5
Total	275	201	242	220	185
Fresh—					
From United States	1,952	1,490	1,775	1,649	1,548
From other countries	128	318	329	542	332
Total	2,080	1,808	2,104	2,191	1,880
Hams:					
From United States	1,131	921	1,075	1,203	984
From other countries	122	67	55	86	133
Total	1,253	988	1,130	1,289	1,117
Meat, unenumerated:					
Salted or fresh—					
From United States	21	22	34	37	42
From other countries	130	156	156	200	165
Total	151	178	190	237	207
Preserved otherwise than by salting—					
Beef	569	386	291	471	284
Mutton	68	84	113	200	106
Other sorts	163	121	150	185	142
Total	800	591	554	856	532
Mutton, fresh:					
From Holland	165	197	200	167	122
From Australasia	977	1,187	1,440	1,672	1,451
From Argentina	471	516	586	715	608
From other countries	87	71	70	57	6
Total	1,700	1,971	2,296	2,611	2,187

Quantity of meat imported into the United Kingdom, etc.—Continued.

Meat product.	1892.	1893.	1894.	1895.	1896 (9 mos.).
Pork:					
Salted (not hams)—	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*	*Cwt.*
From United States	162	111	150	123	99
From other countries	66	76	75	97	94
Total	228	187	225	220	193
Fresh—					
From Holland	92	120	134	249	143
From Belgium	23	25	31	27	17
From other countries	17	37	16	12	
Total	132	182	181	288	167
Rabbits:					
From Belgium	89	83	86	86	48
From other countries	19	21	22	34	53
Total	108	104	108	120	101
Total meat	10,608	9,409	10,720	12,095	9,992

NOTE.—Cwt.=112 pounds.

BRITISH IMPORTS OF LIVE ANIMALS.

In connection with the foregoing, the appended table shows how many oxen, bulls, cows, and calves have been landed in Great Britain from foreign ports during the same period of time:

Number of live animals (for food) imported into the United Kingdom in the years 1893, 1894, 1895, and the first nine months of 1896.

Animals.	1893.	1894.	1895.	1896 (9 months).
Oxen and bulls:				
From Canada	81,232	80,450	95,747	71,670
From United States	248,825	381,657	276,307	308,159
From other countries	7,006	9,687	41,283	56,394
Total	337,063	471,794	413,337	436,223
Cows:				
From Canada	1,690	1,868	234	1,673
From United States	66	265	31	161
From other countries	1,152	1,380	1,615	1,069
Total	2,908	3,513	1,880	2,903
Calves:				
From Canada	3	5	12	
From other countries	71	128	336	161
Total	74	133	348	162
Oxen and bulls	337,063	471,794	413,337	436,223
Cows	2,908	3,513	1,880	2,903
Calves	74	133	348	162
Total cattle	340,045	475,440	415,565	439,288
Sheep and lambs	62,682	484,597	1,065,470	614,855
Swine	138	8	321	1

AMERICAN SHEEP IN ENGLAND.

American sheep during the year 1896 have been landed in Liverpool in greater numbers than during any preceding year. They have consisted largely of corn-fattened muttons, and nine-tenths have been of superior quality.

The profitable market for mutton in England appears to have encouraged sheep growing and fattening in many of the Western States. Although prices fluctuate considerably, being regulated by the supply and prices of native English mutton, there is, as a rule, only a difference of about 3 cents per pound between the best English and the best United States mutton. This is not because of English prejudice against the American article, but because many of the sheep from the United States, having been rapidly fattened on corn prior to shipment, show sometimes 80 per cent of their added weight to be tallow, while the flesh (Englishmen declare) is flavored by the corn feed.

American yearlings and 2-year-olds command practically the same price as English sheep of the same age and quality, and have sold during the present year at from 14 to 16 cents per pound.

It was, however, the misfortune of American shippers, notwithstanding the increased vigilance and rigor of the inspection of animals for export, to have landed during the year 1895–96 a few lots of sheep in Liverpool and London affected with the scab. It is quite possible that this disease was generated by infected ships upon which diseased sheep had been sent from Argentina and other countries, and then, without proper disinfection, had been put into the carrying trade between the United States and Europe. It is, however, believed that if sheep are wet and crowded during a voyage, scab may be generated by those conditions.

The Glasgow market finds fault with American sheep, and also with Canadian, by declaring them too big and too fat. The Scotch want medium weights, and for them will pay high prices. Foreign markets demand some other breed of sheep for mutton than the Merino and its crosses, and those looking to profitable ventures in this line should secure the best mutton breeds of sheep, which, when they are landed in as good condition as American cattle, will soon have as high a reputation and bring as remunerative figures.

IMPORTS OF HOG PRODUCTS.

Great Britain continues the largest purchaser and importer of swine flesh and hog products in the world.

In 1893 British consumers took from foreign countries 3,000,000 hundredweight, over 3,500,000 hundredweight in 1894, more than 4,000,000 hundredweight in 1895, and nearly 3,500,000 hundredweight during the first nine months of 1896. This year will, therefore, show a large increase in consumption. It is noticeable that

while there was an increase of 800,000 hundredweight in 1895 over 1893 the value fell from $41,250,000 to $38,500,000.

Shipments from the United States of these products are pretty steady and average 2,500,000 hundredweight a year. American packers are not participating in the profits of the growth in consumption of swine flesh and hog products in Great Britain as much as they ought to, because they do not cure meats especially suited to the English demand. But their Danish and Canadian competitors are increasing their shipments into the United Kingdom every year. This is because the packers of Denmark and Canada are carefully catering to the taste of the English consumer. Eighty per cent of the entire Danish product finds market in England. The cost of swine at the packing houses in Denmark is given at 6 cents a pound live weight, with a dockage of 20 per cent on refuse, together with 28 pounds of bone. The freight on the product to London is only $7.30 per ton, and the price realized is about $11 per 100 pounds.

Irish packers are more damaged by Danish competition than are those of the United States, and the great abattoirs of Ireland are advocating improvement in breed of swine for that country, and also in the methods of curing the meat for market.

GROWTH OF DANISH PACKING BUSINESS.

An indication of the growth of the Danish packing business and its possible effect upon competitors in the English market is submitted from the Ulster Curers' Association, and reads as follows:

> Prior to 1886 the bacon-curing industry was practically unknown in Denmark. Since that time the Danes have not only learned the business of curing so as to please the most fastidious English markets, but have introduced from England and established a breed of pigs exactly suited to the wants of the curer in point of leanness, with the result that the feeder gets the utmost price possible from the curer, and his loss through raising overfat, unsuitable meat is reduced to an absolute minimum. In other words, rearing and feeding of pigs are conducted on scientific principles. Success has been achieved through the dissemination through the agricultural districts of Denmark of the knowledge of trained experts acting with State aid and under State supervision.
>
> Grants have been made by the Danish Government, through the Royal Danish Agricultural Society, for the purchase in England of swine of the best breeds and most suitable for crossing with the native stock for the production of pigs for curing purposes. The disbursement of the money granted has been in the hands of experts, who made frequent visits to England, purchasing stock from the best-known pedigree herds of the country. In addition to the money thus expended, the Danish Government adds subventions to railway and steamship companies, and supports experts qualified to instruct the bacon factors in the better preparation of their product for the English market.

LOW PRICE OF AMERICAN BACON IN ENGLAND.

Our bacon sells for less money in the English market than that of any other country. The reason for this is found in its overfatness and saltness. When bacon prices are depressed, the lower grades are

proportionately more depressed than the higher. Therefore American bacon ranges from about 2 cents per pound wholesale below Continental and Irish bacon and about 3 cents below English bacon. American bacon in the English market will bring a better price when it is prepared with a view of meeting the tastes and demands of English people. But to-day American packers merely dump their overflow product upon the English market for what it will bring, and leave the higher prices to English, Canadian, and Danish packers.

American hams are held in higher estimation than bacon and hold their own in competition with all other countries, so that in quantities shipped and in prices hams and pickled pork from the United States are equal to the same products from other countries.

AMERICAN HORSES IN ENGLAND.

In the year 1893 Great Britain took 13,707 American horses. In 1894 the same purchaser received from the United States 22,866 horses, and in 1895, 34,092. But during the first nine months of the year 1896 there had been shipped from the United States to England 34,642 head of horses. Shipments by Canada have increased during the same period of time in about the same proportion, while shipments from the Continent of Europe have fallen off materially; so that it may now safely be claimed that the United Kingdom looks to America for all the horse supply which she once purchased principally from Germany.

American horses are now in steady demand for omnibus, street-railroad, and cab services, and for the use of traders who keep drays, vans, and carts for the collection and delivery of goods. English breeders are turning their attention chiefly to hacks, hunters, and heavy draft horses. Large, compactly built, healthy draft horses are high in price, with a constant market. The demand for these animals is on account of the omnibuses, cabs, and trucks, and those from the United States are growing in favor. The strongest recommendation for American horses is their staying qualities—their powers of endurance. Horses suited to cab work bring from $55 to $100. A better class of animals commands readily from $125 to $150, and the average price is not below or above those figures.

Draft horses from the United States are in great demand and the trade in this style of animals may greatly develop, as the American draft horse is regarded as of better action and life than most of the native breeds. During the summer of 1896, in English markets, these animals have sold at $250 to $280 a head, but they were of first-class quality. The veterinary superintendent of the city of London commends the American stock of horses in that market very highly. All horses from the United States and Canada are inspected under the direction of the British Board of Agriculture upon their debarkation at any English port, and thus far during the year 1896 the sanitary condition of animals landed has been reported very good.

AMERICAN APPLES IN ENGLAND.

The season begins in England for apples in August, when the domestic crops come into the market. At this time the stores are full of other fruits, and apples are comparatively neglected and bring low prices. It sometimes happens that a very large crop in Spain and Portugal will result in limited shipments to England during August and September, but with this occasional exception the supplies are confined to the home product. The Spanish and Portuguese apples are of inferior quality, and bring only the moderate price of from $1 to $1.75 per hundredweight of 112 pounds. The bulk of the English apples in average years would sell at about the same rate, superior kinds bringing much higher prices. In ordinary seasons English apples are to be seen in the English markets up to the end of January. In 1896, however, the crop was deficient both in quantity and quality, and was practically used up by the beginning of October. The market was thus left clear for United States and Canadian fruit, which is the chief, indeed practically the only, source of supply during the winter. As usually happens, our earlier shipments were not representative in quality, and brought low prices.

Our packers send their fruit forward in barrels which net as a rule not quite 100 pounds. Our European agent has heard complaints that there is a tendency toward a decrease in the size of the barrels, and this is a mistake from a business point of view. The Canadian barrels weigh gross about 1½ hundredweight (say 168 pounds) and net 130 to 140 pounds. When people see Canadian Baldwins quoted at $2.50 to $3.25 per barrel and United States Baldwins quoted at $2 to $3, they are apt to consider this evidence of superior quality and higher price for the Canadians. It is, however, merely the difference in the weight of the barrel.

PREFERRED VARIETIES.

The big bulk of the shipments consists of the Baldwins, Northern Spys, and Greenings. Our Baldwins are finer and larger than the Canadians, but they are not so hard and not such "good keepers." They range as a rule from $2.50 to $3.50 for Canadian barrels, and $2 to $2.75 for American. It is not believed in England that these prices will be quite established during the winter of 1896–97 on account of the immense crop reported to have been gathered in the United States and Canada.

The Greenings are not so attractive in appearance, but they have a firm hold on the English market for cooking purposes, more especially in the north. Good, clear, unspotted Greenings bring in the ordinary season from $2.50 to $3.50 per Canadian barrel, an extra price being paid for large apples. Special importance is attached to size in the case of Greenings; buyers willingly pay enhanced prices for large specimens, as a rule cooking them in the form of dumplings. Small

Greenings would easily fall off a dollar a barrel in price, and thus render the shipment unremunerative.

Northern Spys usually bring about the same prices as the Baldwins.

Freights to London, Liverpool, Glasgow, or Bristol are approximately $1 per barrel, and all charges, including auctioneer's commission, would be covered by 25 cents. All apples are sent on consignment to brokers who effect sales by auction. The business is cash on delivery, and if the auctioneer gives credit it is at his risk, and not at that of the seller. The Department representative in England is prepared to give inquirers the addresses of respectable consignees in the principal seaports of Great Britain.

The Spitzenberg is a good, reliable apple, appreciated in the English market, and it brings about the same price as the Baldwin. Indeed, nearly all red-colored apples bring about the same prices.

Russets are liked and sell at about the price of the Baldwin. Golden Russets, if carefully selected, would bring from 50 to 75 cents over the average. The tendency with Golden Russets arriving in England is, however, toward such a small size that they do not make over average prices. The Roxbury Russet is also a favorite.

Apples of superior varieties, like Newtown or Albemarle pippins, and superior apples of ordinary varieties, may be depended upon to bring their value. Twenty-ounce Pippins, Cranberry Pippins, "Kings," and Ribstones, for instance, of large size and good color, would range from $3.25 to $4.50 per Canadian barrel, when good Baldwins were selling for $2.50 to $3.25.

SUGGESTIONS TO SHIPPERS.

Any apple of good color and fair size will sell in England if sound, but the profit is made in sending something better than the average. It costs no more to send a fine barrel of apples across the Atlantic than to send a medium barrel, and the return is better. The utmost care should be taken in the selection of the fruit. "If you discard a shilling's worth in packing, you may better your price 2 shillings," is the saying of a London broker. The fruit should be so packed that it can not shake together. It should arrive tight. If buyers find a barrel that rattles, it will reduce values from 25 to 50 cents, even though the contents be entirely uninjured. On the other hand, care should be taken that the fruit be not pressed too tight, for if the top layer is bruised or unduly flattened it reduces the price from 50 cents to $1. A few consignments have reached England in boxes from time to time, but there is no apparent advantage in boxing, though Tasmanian apples are thus forwarded. In a good season "fancy brands" of apples of exceptional quality and appearance might perhaps be advantageously shipped in small boxes, but the fruit must be very special or the enhanced cost of the small boxes is not recouped.

ECONOMICS FOR THE FARMER.

Agricultural colleges and experiment stations are teaching the science of agriculture. But they are not generally teaching farm economics and the importance of markets. Science is constantly showing the farmer how to increase the annual product per acre in cereals and other staples, but the great question confronting each tiller of the soil is how to secure satisfactory remuneration for the results of his toil. In view of this, it is a legitimate function of the Department of Agriculture to place before the farmers of the United States as many facts and figures relative to markets as it is possible to obtain.

WORK OF THE SECTION OF FOREIGN MARKETS.

In furtherance of this design, the Section of Foreign Markets was organized on March 20, 1894, for the purpose of collecting and disseminating information calculated to assist in securing a more extended market abroad for the agricultural products of the United States. The work of the section, with this object in view, is twofold in character. It comprises not only the publication of a regular series of bulletins and circulars, but also the furnishing of information in response to special inquiries. Eight bulletins relating to as many different countries, viz, the United Kingdom of Great Britain and Ireland, the German Empire, France, Canada, Netherlands, Belgium, Norway, and Sweden, have already been issued, and bulletins upon Denmark and Mexico are now in course of preparation. Each country is treated with a view to its possibilities as a customer of the United States.

The natural resources of the country are described in some detail, and also the character and extent of the leading productive industries, but more especial attention is given to the subject of foreign commerce. A detailed statement of the principal articles of merchandise imported and the various sources from which they are received is presented, together with such information regarding customs duties and regulations, equivalents of foreign weights and measures, rates of exchange, etc., as may be of service to American producers seeking a foreign market for their products. Appended to each bulletin is a series of reports received through the medium of the State Department from our consular representatives abroad. These consular reports are designed to set forth such opportunities as exist for increased trade with the United States, and they frequently contain information of great value to American exporters.

In addition to the bulletins described, the Section of Foreign Markets has thus far issued ten special circulars upon subjects affecting our foreign commerce. The statistical data presented in the bulletins and circulars of the section are derived as far as possible from the

official publications of the countries treated, and to render their statistics more readily intelligible, foreign moneys, weights, and measures are converted into their equivalents in the denominations used in the United States.

An important part of the work of the Section of Foreign Markets consists in supplying information in response to the many inquiries that are received relative to the extension of our foreign trade. These inquiries cover a wide range of investigation, and it frequently entails a large amount of labor to supply the information desired. Among the sources of inquiry to which information has been furnished may be mentioned other Departments and offices of the Government, Representatives in Congress, and Congressional committees, boards of trade, chambers of commerce, and other commercial and agricultural organizations, and newspapers and periodicals devoted to agriculture or trade.

The numerous requests for information received by the section and the large demand for its publications serve in a measure to indicate the importance of the work that it is attempting to perform. The rapid development of the agricultural resources of the United States has resulted in an annual production far in excess of the consuming capacity of our population. To such a degree has the surplus increased that its disposal is fast becoming a grave problem. The logical solution lies in the extension of our markets beyond the sea. To accomplish this in the face of the keen competition that other great producing countries are prepared to offer, an accurate and thorough knowledge of the conditions to be met is quite essential. The investigation of these conditions and the diffusion of the information thus acquired comprise the work for which the Section of Foreign Markets was created.

WORK OF THE WEATHER BUREAU.

During the last twelve months marked and valuable improvements have been made in the Weather Bureau. Accurate forecasts of the weather are the most valuable service rendered by this Bureau to the general public. Storm warnings, forecasts of falling temperature, and predictions of other atmospheric changes and phenomena have been very satisfactorily and oftentimes perfectly verified during the past year. More than 10,000 cities, villages, and towns have been added to the list of beneficiaries of the Weather Bureau service in the same time, and expenditures have been less than for any twelve months during the past fifteen years, except one, in which they were substantially the same.

New and ingenious inventions have been furnished to the principal observer stations for the purpose of expeditiously printing, in a more legible manner, the daily Weather Bureau maps which are posted in the leading cities and towns of the country, while the methods for

distributing the useful information furnished by the Bureau have been greatly perfected and extended, through the mails, to the smaller villages and post-offices.

A Weather Bureau service especially for the benefit of the cereal growers has also been established, so that now the area producing that staple is served in precisely the same manner as those vast areas which produce cotton.

TIMELY WARNINGS.

Warnings have been heralded and signals displayed throughout the country well in advance of all the cold waves of any intensity which have occurred during the year. The value of such warnings was especially appreciated when the severe cold wave which swept, between January 1 to 5, 1896, from the northern Rocky Mountain region southward to the Gulf of Mexico and eastward over all the States along the Atlantic Ocean was forecasted and afterwards verified. Congratulatory acknowledgments from commercial bodies and from shippers of perishable merchandise indicate a saving through the various storm warnings similar to the above of several millions of dollars. Warnings of approaching cold waves of intense freezing power enabled owners of perishable property to protect their commodities in time, and the warnings thus rendered inestimable benefit to commerce.

Hurricane forecasts have been given to people along the Atlantic Coast several times and with the best of results to shippers and shipping. Three severe West India hurricanes swept the coast of the United States from Florida to New England and two others passed offshore, but sufficiently near to seriously endanger the craft just leaving port. Twenty-four hours or more in advance of each of these storms, danger signals announced their coming. Not a single vessel was lost, and comparatively little property was destroyed belonging to those who heeded the warnings. On the Great Lakes a similar system has been inaugurated and successfully operated. In the harbor of Buffalo alone during the last winter a total of more than 150 vessels, aggregating millions of dollars in value and having thousands of persons on board, were detained in port by the Weather Bureau forecasts, without which every one of the vessels would have been jeopardized in perilous storms.

No very great floods have occurred in or along our big rivers during the past year, though the sudden melting of the snow at the head waters of the Allegheny caused a moderate freshet in the Ohio River in the latter part of March and in the beginning of April, 1896. A warning, however, had been issued by the Weather Bureau and prevented much loss of property. During July of the last summer unusually heavy rains prevailed in the South and Middle Atlantic States which caused floods in the rivers of Virginia, North Carolina, and South Carolina. From those States the Weather Bureau received

reports showing a saving in stock, crops, and merchandise on the lowlands amounting to thousands of dollars, and also stating that vast values of logs and other property on these rivers were likewise saved as a result of the timely admonitions.

The Chief of the Weather Bureau shows in his annual report that the average verification of forecasts during the year was 82.4 per cent. This is an improvement of 2 per cent over the previous year. The Bureau continues its investigations in the science of meteorology. Prominence has been given during the year to the subject of aerial investigations. Much work has been devoted to the development of appliances for upper-air exploration. The future will demonstrate the value of these incursions into the upper strata of the atmosphere.

AGRICULTURAL PUBLICATIONS.

During the fiscal year 376 publications were put out by the United States Department of Agriculture, principally for gratuitous circulation. They aggregated six million five hundred and sixty-one thousand seven hundred (6,561,700) copies. The total number of pages is, however, less than were contained in the 254 publications of the previous year, and even less than those in the 205 publications of the year 1894. The policy of condensation and abbreviation has been firmly established as to bulletins and circulars issuing from this Department. By a careful and critical editing of the matter sent into the Division of Publications, terseness and lucidity have been stamped upon all agricultural literature disseminated by the Department.

Farmers' Bulletins, two-thirds of which are distributed by Senators, Representatives, and Delegates in Congress, were printed to the number of one million eight hundred and ninety-one thousand (1,891,000) copies, and, of those, one million three hundred and sixteen thousand six hundred and ninety-five (1,316,695) copies were delivered to Senators, Representatives, and Delegates. The average cost of Farmers' Bulletins during the year was 1.3 cents each.

MODIFICATION IN METHOD OF DISTRIBUTING PUBLICATIONS.

The method of distributing Department publications has been materially modified and improved under the act of January 12, 1895. The mailing lists of the Department have been carefully revised. They include now only those who render some reciprocal service, or who, from educational or official position, are entitled to recognition. Besides those persons, universities, colleges, academies, and public libraries receive publications of the Department when they apply for them. Remaining publications not required for distribution by the Department, as above outlined, are transmitted to the Superintendent of Documents. He holds them for sale at prices barely adequate to pay for their printing. Up to June 30, 1896, the number sold by that officer was 2,818.

THE RESTRICTION IN REGARD TO 100 PAGES.

The act referred to is, however, in need of amendments. It limits to 1,000 copies every publication exceeding 100 octavo pages, unless otherwise ordered by Congress. This proviso has seriously interfered with the utility of the Department in its lawful and prescribed duty of disseminating information in accordance with the law creating the Department. Legally, under the present method of distribution, only those persons decided to be properly entitled to them, may receive publications free of charge. Therefore, the thousand copies' limitation is an unnecessary and inequitable restriction, and does injustice to many citizens who are actively and usefully cooperating with the Department for the love of agriculture itself and without pecuniary remuneration.

DISCOURAGEMENT OF PRIVATE ENTERPRISE.

The Public Printer may, under this law, supply at cost to parties asking for them while the work is in press a limited number (not exceeding 250 copies) of any publication. For electrotype plates of the same he is required to charge an amount sufficient to cover the entire cost, including composition, manufacture of the plates, and 10 per cent additional. These provisions limit the distribution of the publications containing useful information while they save the Government nothing. Such sales ought to be made only upon the approval of the head of the Department and subject to regulations made by the Public Printer, but some method should be adopted by which the publications of the Department of Agriculture, at least, may be indefinitely multiplied without public cost and by private enterprise.

Neither the Department of Agriculture nor the Government itself can continue for the next five years, even, to increase its publications for gratuitous distribution in the same ratio that such publications have increased during the last five years without disbursing many millions of dollars. Many good citizens disapprove of the Government or any Department thereof becoming a competitor with the authors and publishers of books relating to pisciculture, geology, horticulture, entomology, agriculture, and kindred sciences. And it is frequently asked why discriminations should be made and useful literature published by the Government and circulated gratuitously among the people upon a particular line of subjects, employments, and interests, while all other vocations are left to think out and publish their own literature.

NEED OF GREATER ECONOMY.

While the act of January 12, 1895, was presumably designed to effect economy in the work of publications, and while it has to some extent fulfilled this design in the way of limiting the free promiscuous

distribution of Government documents, it has in some respects increased rather than decreased expenses. The expense of conducting the branch printing office of this Department under the conditions imposed by the act in question amounts to $16,000 yearly, which is considerably more than twice as much as it has cost previously, and though there has been marked improvement in both the quantity and quality of the work, the increased expense has been disproportionate to the benefits obtained. As regards the economy effected under the act by reason of the restrictions which it permits—and in fact enjoins—in the distribution of public documents, it is discouraging in the extreme to find efforts at economy in this direction neutralized by special appropriations for the printing and free distribution of certain publications, the need for which exists in some cases so little that not a single copy is provided for the use of this Department, notwithstanding the fact that the cost of the work is deliberately added to the appropriations estimated for as necessary by the Secretary of Agriculture. In the act making appropriations for this Department for the current fiscal year, $82,500 was so added for the purpose of printing 60,000 copies each of the Report upon the Diseases of the Horse and the Report upon Diseases of Cattle, to be given away by Congress.

Strenuous efforts have been made by the present Secretary in behalf of economy in this line as well as in others. And yet the increased number of publications have made it necessary to ask for an appropriation for printing in this Department of nearly $100,000, and also for a further increase in the appropriation for the editing, illustrating, and distributing of the carloads of matter yearly evolved by the several bureaus and divisions.

GROWTH OF PUBLICATION WORK.

The Division of Publications now embraces the work of distribution. Heretofore it included only editing and illustrating. The several appropriations expended under the direction of Mr. George William Hill, chief of this division, aggregate $170,000. The total appropriation of 1896 is considerably less than 50 per cent over that made for 1894, while the number of publications issued exceeds this year by 85 per cent those issued in 1894, and the total number of copies is 100 per cent greater. This is sufficient evidence that the appropriations for this division have been carefully, efficiently, and economically handled, and that the increase of money disbursed is unavoidable simply owing to the constantly increasing issue of publications by the Department.

In 1891 appropriations for the purposes of publication in the United States Department of Agriculture amounted to $87,600. Only 124 bulletins, pamphlets, and other documents were issued, and the total number of copies printed was 2,384,447. But during the year 1896

appropriations of $172,740 paid for the 376 publications, numbering 6,561,700 copies. The increase in expenditure was less than 100 per cent, the increase in number of publications more than 300 per cent, and the increase in the number of copies distributed 175 per cent. And during the year 1896 the salary list of the Division of Publications, including work of editing, illustrating, and all other office labor involved, has been actually less than it was in 1891.

In view of the foregoing facts, the estimates for the work of the Division of Publications for the next fiscal year must, it is believed, commend themselves as reasonable and necessary.

GRATUITOUS SEED DISTRIBUTION BY THE GOVERNMENT.

The contract for furnishing vegetable and garden seeds during the fiscal year 1896 was made with D. Landreth & Sons, of Philadelphia, Pa., and that for flower seeds was made with L. L. May & Co., of St. Paul, Minn. Both contracts were let after consultation with and by and with the advice and approval of the chairmen of the Committees on Agriculture in the United States Senate and House of Representatives.

The dissemination is tabulated and made explicit by well-considered figures in the report of the special agent who had the matter in charge.

The seeds distributed gratuitously by the Government during the fiscal year closing on the 30th of June last weighed a little over 230 tons. The cost of carrying them through the mails was over $70,000. They occupied 30 mail cars in transportation.

Careful computation shows that the seeds sent out by the Department of Agriculture during the year would have planted 21,038 acres of cabbage, 10,768 acres of lettuce, 10,712 acres of tomatoes, and other garden vegetables in proportionally large areas. Briefly, the seed gratuitously sent about the country would have planted more than 115 square miles of garden. In other words, it would have planted a strip of ground 1 rod in width and 36,817 miles in length. Such a strip would reach one and one-half times around the globe, and a passenger train going at the rate of 60 miles an hour would require 51 days 3 hours and 14 minutes to travel from one end of this gratuitously seeded truck patch to the other.

Each Congressional quota contained seed enough to plant more than 163½ acres.

The 10,125,000 packets of vegetable seeds cost the Government $75,000, while the transportation of the same through the mails added the sum of $74,520, making a total cost directly to the Government of $149,520 for the gratuity, paid for by money raised from all the people, and bestowed upon a few people.

Samples of all seeds sent out were carefully and thoroughly tested by Mr. Gilbert H. Hicks, expert, as to purity and germinative power. A complete record has been kept of all the shipments of blank franks

and also of the miscellaneous lots of addressed franks from each Senator and Member of Congress, and receipts have been taken from the postmaster and postal clerk furnished by the Post-Office Department during the shipment of the seeds. Records of the mail packages show by whose orders they were mailed, to whom sent, the post-office address, and the dates they were sent out.

CONTRACTS FOR CURRENT YEAR'S DISTRIBUTION.

For the year ending June 30, 1897, seeds have been contracted for amounting to $130,000 in value. Owing to lower prices, it is safe to say that each Congressional quota will be nearly double what it was in the year 1896. And careful estimates make it obvious that the gratuitous distribution of seed by the Government during the year 1897 will amount, at retail price valuation, to more than $2,000,000. And because of this competition of free seed with the retail seedsmen of the country, an attempt was made recently to enjoin the Department from purchasing seed with the appropriation made at the last session of Congress. But the injunction was denied, and thus the great privilege of gratuitously furnishing garden and flower seeds to a small per cent of the people out of money raised from the revenues of all the people was conserved to Members of Congress and the officers of the Department of Agriculture. It is estimated that the distribution for this year will be sufficient to plant about 230 square miles of ground, and will therefore employ in the distribution about 60 mail cars.

The Secretary of Agriculture sincerely regrets this unnecessary and wasteful expenditure of public moneys, and hopes that Congress may in good time put a stop thereto.

EXPERIMENT STATIONS.

By authority of act of Congress making appropriations for the Department of Agriculture for the fiscal year ending June 30, 1896, and also in subsequent acts, examination of the work and supervision of the expenditures of the agricultural experiment stations established under act of March 2, 1887, have been made. A report of these investigations has been sent to Congress. It shows that the operations of a majority of the experiment stations have been within the scope and letter of the law. Some stations, however, are still defective in their organization and work. They do not use sufficient care in the expenditure of the funds as provided for by the terms of their organic act.

The expansion of the experiment station enterprise immediately following the passage of that organic act was too rapid to be either wise or deliberate. It necessitated the employment of many officers who had not proper scientific education or experience. Imperfect comprehension of the functions and duties of experiment stations on the

part of governing boards and officers intrusted with the management of the stations has in many instances led to misdirected effort; in some to superficial work, and in others to expenditure of the public funds for work not contemplated in the original act.

It was, however, impossible to organize, simultaneously, fifty or sixty new institutions for original scientific research of an entirely novel character without falling into many errors. This criticism, therefore, of misdirected efforts is meant for the few and not for all.

Some institutions have made the error of confusing work and expenditure intended for instruction with that intended for experimentation. Some stations expended large sums of money in what may have seemed experimenting, but was in reality the conduct and maintenance of large farms on which general crops (with, perhaps, some improved methods) were produced.

PROPER FUNCTIONS OF EXPERIMENT STATIONS.

The experiment station was not designed to be a model farm. There is neither warrant in law nor justification in circumstances for making it such.

Another seeming misuse of funds has been brought about by the acceptance of donations of farms from enterprising citizens or from communities upon condition that permanent substations should be established upon them. Such farms have been often accepted without properly considering the nature of the soil of the land donated or the real needs of the locality. Thus much money has been wasted for building and equipments upon farms where only superficial and temporary experiments can be conducted.

In some cases too frequent changes in boards of control, resulting in changes of policy with regard to the station and changes in the station staff, have worked great injury and discouragement. An experiment station's proper management has no possible relation to any political party whatsoever. It should be in the hands of the best experienced and most practical scientists of the State or Territory. It should be permitted to go on increasing its utility and establishing its permanence without political interference.

Some stations have endeavored to cover too many lines of work. Many stations were organized originally as so-called "all-around stations." They had a large staff of officers called "agriculturists," "chemists," "botanists," "entomologists," and "horticulturists." They paid small salaries, and, with few facilities for work, achieved small results. Most of the officers were obtained from the agricultural college faculties. They were allowed very little time from their teaching duties therein, and consequently could not thoroughly conduct experimental investigations. In some cases this practice led to an almost total diffusion and exhaustion of the experimental and station funds. Such stations had no definite aim and organization, and sometimes little administrative ability. Every station should have its own

executive head or secretary, like any other department in the college, and he should report to the president or chancellor who represents the controlling board.

FUNDS OF THE STATIONS.

It is regretted that so many of these institutions for higher scientific education in the United States have been limited as to funds with which to make original research; much useful investigation has, however, been carried out by professors connected with them, notwithstanding very limited means, purely from a love of science. Largely this has been accomplished outside of their regular duties and at great inconvenience and expense to themselves personally.

The experiment station act gives the land-grant agricultural colleges $15,000 per annum especially for original research in agriculture. This is equivalent to 5 per cent per annum upon an endowment of $300,000 for each station. And this fund ought to be regarded as a sacred trust and devoted entirely to the advancement of agricultural science through conscientiously directed original research. If this course be pursued in all the institutions, as it has been faithfully pursued in some, practical agriculture will receive vastly increased benefits. The colleges themselves will be greatly strengthened in resources, and will attract to themselves more and better students of agriculture and allied sciences.

A separate account of the funds bestowed by the National Government should be kept by the accounting officer of every college having an experiment station. Care ought to be taken that neither directly nor indirectly shall any part of this specific trust fund be diverted to general college purposes.

REGULATIONS FORMULATED BY THE DEPARTMENT.

Complying with the authority granted by Congress, the United States Department of Agriculture formulated general principles and regulations for the guidance of experiment station expenditures. This was for the purpose of bringing the disbursement of those institutions within the provisions and intent of the law. It is hoped that hereafter these directions will be accurately carried out in every respect. If the United States experiment stations do not universally conform to the literally correct interpretation of the organic act, it will become necessary to amend the law so as to definitely describe the functions of the institutions and absolutely compel a more rigid accounting for the funds appropriated by the Government of the United States.

Investigations made up to this time verify and affirm the wisdom of the recommendations for the expenditure of these moneys under the supervision and direction of officers of the United States which were made by the Secretary of Agriculture in his report for the fiscal

year 1893. The necessity of a governmental and a strict accounting for these funds is generally recognized by the governing boards and officers of all the experiment stations.

PRELIMINARY INVESTIGATIONS IN ALASKA.

Propositions have been made in Congress and elsewhere looking to the establishment of an agricultural experiment station in Alaska, but information as to the present condition and possibilities of agriculture in that Territory is so limited that a recommendation for the establishment of a station therein is not warranted. Until there shall have been made a preliminary examination of the soil and climatic capabilities of Alaska, it is deemed unwise to establish stations therein. But the estimates for appropriations for the coming fiscal year include one of $5,000 for the purpose of making explorations and investigations as to the agricultural resources of that Territory.

NUTRITION INVESTIGATIONS.

The appropriations for looking into the nutritive value of the various articles and commodities used for human food were continued and increased by Congress for the past fiscal year. The supervision of the work accomplished under this appropriation remained in charge of the Office of Experiment Stations, and the general policy pursued was that outlined in previous reports. As stated in the report of the Secretary of Agriculture for the year 1895, the effort has been made "to build up centers of inquiry where the more scientific and fundamental problems can be best investigated, where workers in this line can be efficiently trained, where the importance and usefulness of accurate information regarding the rational nutrition of man will be impressed upon large bodies of students and from which the practical results of food investigations may be widely and efficiently disseminated."

Experiment stations, agricultural colleges, and other educational institutions, as well as some benevolent associations, have joined with the Department in making these valuable investigations. The funds at the disposal of the Department were more economically and efficiently used in the encouragement of researches on the food and nutrition of man at institutions of learning, in various parts of the country, which would contribute the services of experts, laboratories, and other resources, than they could have been in any other way. In nearly every locality where nutrition investigations have been conducted they have been with the cooperation of some institution of learning. Thus the assistance of those especially interested in this kind of research has been secured; thus the inquiries have been rendered more effective; thus the results, besides being reported to the Department, have been disseminated by publications throughout the country, and thus also they have been generally utilized to the

best advantage. Under no other system of operation could so large an amount of good have been accomplished with the appropriations which Congress made for this specific purpose. The data already collated are much more numerous and extensive than could have been obtained in years by the Department alone, unaided by the cooperation of colleges, universities, and their professors.

Reference is made to the report of the Office of Experiment Stations, under whose direction these researches have been pursued, for interesting details of the work.

AGRICULTURAL COLLEGES AND THE CIVIL SERVICE.

In the future may it not be possible for an arrangement to be made, in accordance with law, between the presidents of agricultural colleges and the directors of experiment stations on the one hand and the United States Civil Service Commission on the other hand by which the certificates of the former as to industry, ability, and character will permit their graduates, under the direction of the Secretary of Agriculture, to enter the service without competitive examinations? If a reasonable construction of existing law permits those who have devoted years of study at experiment stations and in agricultural colleges, and thus made themselves especially skilled and expert in specific lines of investigation, to enter the scientific bureaus and divisions of the United States Department of Agriculture after a rigid examination by their preceptors and certification by them as to their merits, will not the country begin at once to realize direct benefits from experiment stations and agricultural colleges which under the present system seem to be wanting?

In short, by a judicious extension of civil-service rules can not the agricultural colleges be increased as to number of students and at the same time made a scientific rendezvous whence the Department of Agriculture may with certainty always draft into its service the highest possible ability and acquirements in specific lines of scientific research?

ACKNOWLEDGMENTS AND RECOMMENDATIONS.

Reviewing the operations of the Department, it is shown that there has been a material advance in the practical utility of the work carried on by the several chiefs of bureaus and divisions of the Department during the last four years. Some lines of investigation have been suspended, and others, notably those of soils and grasses and nutrition investigation, have been instituted. It is believed that the Section of Foreign Markets will prove of great educational and commercial advantage to the farmers of the country. It is also obvious that the improvements which have been made have not added to the burden of the public expense.

In this last report of the present Secretary of Agriculture he acknowledges with cheerfulness the efficient cooperation of the employees of the Department. He likewise gladly acknowledges his indebtedness to the Chief Executive of the nation, who at all times has given his encouragement and support to every effort made in behalf of a businesslike and economical management of this Department.

Estimates for the ensuing year have been discussed carefully by the Secretary and his able assistant and those chiefs of divisions and bureaus whose positions and intelligent zeal have rendered their advice valuable and desirable. The appropriations estimated for the next year are reasonable and just. Whatever useful results may be obtained by their proper disbursement will redound to the honor of the succeeding Secretary of Agriculture, under whose immediate direction they are to be expended.

The recommendations of former reports as to the importance of speedily providing new and adequate buildings for the proper accommodation of the Department of Agriculture are strenuously renewed.

In this connection it is a duty to protest against the inexcusable practice of including in the appropriations for this Department funds to be expended by the heads of other Departments or of bureaus in other Departments over which the Secretary of Agriculture has no supervision or control. For the current fiscal year there was included the sum of $82,500 in the appropriations for the Department of Agriculture for certain publications to be distributed by Members of the Senate and House of Representatives. Over that sum of money and the publications provided for no officer of this Department has the slightest supervision. In the same bill there is an appropriation made of $4,500 for the Geological Survey, which rightfully should have been charged to the Department of the Interior. There is neither equity nor good reason for charging to the account of one Department expenditures which are to be made by the officers of another and for which the head of the Department to which the appropriation is charged can be in nowise held responsible.

THE CONDITION OF AMERICAN FARMERS.

The farmers of the United States hold 72 out of each 100 farms—occupied by their owners—absolutely free from mortgages or other incumbrances. The debts secured by liens upon lands used for tillage and the production of crops aggregate, after throwing out the mortgage indebtedness of railroads and other corporations, less than one-sixth of the total indebtedness of the citizens of the United States secured upon real estate.

Out of each thousand farms in the United States only 282 are mortgaged, and three-fourths of the money represented by the mortgages upon the 282 farms was for the purchase of those farms or for money borrowed to improve those farms. And the prevalent idea that the

West and the South are more heavily burdened with farm mortgages than the East and Northeast sections of the United States is entirely erroneous.

The States along the North Atlantic shores are quite heavily encumbered with farm mortgages, and New Jersey carries a debt of this kind greater, in proportion to its farm valuations, than any State in the American Union.

The constant complaint by the alleged friends of farmers, and by some farmers themselves, is that the Government does nothing for agriculture. In conventions and congresses it has been proclaimed that the farmers of the country are almost universally in debt, despondent, and suffering. Largely these declarations are without foundation. Their utterance is a belittlement of agriculture and an indignity to every intelligent and practical farmer of the United States. The free and independent farmers of this country are not impoverished; they are not mendicants; they are not wards of the Government to be treated to annuities, like Indians upon reservations. On the other hand, they are the representatives of the oldest, most honorable, and most essential occupation of the human race. Upon it all other vocations depend for subsistence and prosperity. The farmer is the copartner of the elements. His intelligently directed efforts are in unison with the light and heat of the sun, and the success of his labors represents the commingling of the raindrops and his own sweat.

Legislation can neither plow nor plant. The intelligent, practical, and successful farmer needs no aid from the Government. The ignorant, impractical, and indolent farmer deserves none. It is not the business of Government to legislate in behalf of any class of citizens because they are engaged in any specific calling, no matter how essential the calling may be to the needs and comforts of civilization. Lawmakers can not erase natural laws nor restrict or efface the operation of economic laws. It is a beneficent arrangement of the order of things and the conditions of human life that legislators are not permitted to repeal, amend, or revise the laws of production and distribution.

EFFECTS OF THE HOMESTEAD LAW.

The attention of those who complain of the condition of the American farmer and the hardships which, by stress of the competition of all the farmers of all the world, he is at times compelled to endure, is called to the fact that nearly 2,000,000 of farms of 80 acres each in the United States have been given away by the Government under the homestead act of 1866, during the last thirty years. Those farms contain many millions of acres of arable land.

This giving of something for nothing has resulted in an abnormally rapid increase of the acreage under tillage in the United States during the last thirty years. This also has caused decline in farm land values in the Eastern and older States. Under the timber-culture

law the amount donated was equivalent to over 550,000 more farms of the same size. This takes no account of the desert-land laws, under which numberless choice locations were given away, or of the large body of land patented to States and corporations and sold at merely nominal prices to build up the country. Lands long tilled and rendered partially infertile could not, of course, enhance in value and sell in competition with virgin soil which was being donated by the General Government. Lines of rail transportation have either pioneered the homestead lands or quickly followed their settlement. Reduction in the cost of carriage has made the long haul of the products from those far-away—given-away—farms but a trifle more than the freight upon products grown in the Middle and Eastern States going to the same domestic markets or to those of Europe.

No legislation relative to the public domain has been so directly inimical to the farmers who had bought and paid for the lands upon which they lived and labored. Until the homestead law came into vigor, in 1866, the farmers of the United States competed with each other upon land representing accumulated capital and fixed investments, but after the homestead-law lands began to produce and ship into market crops from the vast area of fertility which they represent, Eastern and Middle States' land values declined. It was impossible for them to enhance in competition with fresher and more productive land obtained as gratuities by other farmers. It was equally impossible—demand remaining stationary and supply suddenly increasing—for farmers in the older States to profitably sell their products in competition with those of the newer States grown upon lands which cost their owners nothing.

RATES OF INTEREST UPON FARM MORTGAGES IN THE UNITED STATES.

Many misinformed persons have declared in their lamentations as to the alleged wrongs of farmers that even money lenders charge greater rates of interest for money loaned upon lands occupied as farms than for that loaned upon other kinds of real estate. So much has been said relative to this subject that it becomes a duty to present in indubitable shape the facts and figures regarding interest upon farm-land loans.

The rate of interest charged on mortgages upon homes—that is, residential property other than farms—averages throughout the United States eighty-four one-hundredths of 1 per cent less than the rate of interest charged upon farm loans. In seventeen States the average rate charged on the latter loans is less than that demanded for loans upon other homes and residential property. In two States the rates are the same upon urban and rural real estate. In Pennsylvania, Maryland, Virginia, West Virginia, Kentucky, Michigan, Wisconsin, Iowa, and Kansas, and in Texas and Alabama, the rates of interest are less upon money secured by farm mortgages than they are in those States upon money secured by other realty.

In five States, including Kansas, the difference in favor of the farmer is from one-fourth to one-half of 1 per cent per annum, and in Texas it is over 1 per cent.

The agriculturist is not discriminated against as compared with any other class of citizens when he comes to borrow money. But if the Western farmer does pay a somewhat higher rate of interest than he would have to pay in the East, so does the Western merchant, lumberman, banker, common carrier, or manufacturer also have to pay a higher rate than persons engaged in the same business nearer the money centers.

During the last ten years in the Western States there has been a steady maintenance of land values in nearly all sections, and in some an enhancement of the prices of land. Between 1880 and 1890 the increase of farming-land values, as reported by the occupants of the farms themselves, was more than enough to offset the entire interest charge for the decade in most of the great agricultural States of the West and South. In Kansas and Nebraska the increase of land values in that period of time exceeded the entire farm incumbrance, principal and interest. In the States of Washington and California it was nearly twice as great as the combined principal and interest. In fact, where the interest was highest the increase in value was greatest.

Average interest rate per annum on farm mortgages in force in 1890.

	Per cent.
North Atlantic States	5.62
South Atlantic States	6.64
North Central States	7.43
South Central States	8.05
Western States[1]	9.08
The United States	7.07

Taking the country as a whole, the most numerous class of farm mortgages and that representing the largest total incumbrance was the class that paid 6 per cent.

North Atlantic Group.

	Per cent.
Proportion of farm mortgages paying 5 per cent interest, or under	30.60
Proportion paying not more than 6 per cent	98.16

North Central Group.

Proportion paying not more than 6 per cent interest	21.34
Proportion paying not more than 7 per cent interest	51.60
Proportion paying not more than 8 per cent interest	83.54

Western Group.

Proportion paying not more than 8 per cent interest	37.74
Proportion paying not more than 10 per cent interest	88.14

[1] Rocky Mountain region and Pacific Slope.

Typical States and average rates of interest on farm mortgages.

	Per cent.		Per cent.
Pennsylvania	5.43	Minnesota	8.18
Massachusetts	5.58	Nebraska	8.22
New York	5.66	Colorado	9.23
Ohio	6.68	South Dakota	9.52
Indiana	6.89	North Dakota	9.54
Illinois	6.92	Wyoming	10.92
Wisconsin	6.64	Idaho	10.55
Michigan	7.10	Utah	10.13
Iowa	7.36	Washington	9.87
Missouri	7.93	Oregon	9.06
Kansas	8.15	California	8.78

RECENT ANNUAL SALES OF FARM PRODUCTS ABROAD.

Attention is called to the fact that during the fiscal year just ended the exported products of American farms aggregated a value of $570,000,000. That is a gain of $17,000,000 over the preceding year. During the fiscal year 1896 agricultural products make up only 66 per cent of the total exports of the United States, as against 70 per cent in 1895, 72 per cent in 1894, and 74 per cent in 1893. But the reason of a relatively decreased value of 4 per cent, with an increase in the absolute valuation of agricultural products shipped in the year 1896, amounting to $17,000,000 more than those of the preceding year, 1895, is solely due to the unprecedented sale abroad of American manufactured goods and commodities, the exports of which from the United States jumped from a valuation of one hundred and eighty-four millions of dollars ($184,000,000) in 1895 to two hundred and twenty-eight millions of dollars ($228,000,000) in 1896.

GENERAL PROSPERITY DEPENDENT UPON AGRICULTURAL PROSPERITY.

It is admitted by all economists that general prosperity depends absolutely upon agricultural prosperity. The largest market for the products of agriculture and for the products of the manufactories is admittedly the home market. It is, however, true that the export trade is the regulator, the balance wheel, for domestic trade. Therefore, it follows that the interest of the manufacturer, as well as of the farmer, is found in the most rapid possible increase of the export of farm products. By such exportations farmers and those engaged in subsidiary arts, who constitute nearly one-half of the population of the United States, and who mainly create the demands of the home market for manufactured goods, will have an increasing power to buy those goods. On the other hand, the imported products of agriculture are limited in number. They are mainly sugar, wool, hemp, coffee, tropical fruits, and nuts.

Any commercial system which will increase with celerity and extend with certainty the export of farm products from this country will be

of the utmost advantage to agriculture and all those interested in its profitable expansion. And that political economy which best advances the interests of the agriculturists furnishes the best impetus to the manufacturers of the United States, because when the prosperity of the American farmer is established by virtue of constantly increasing sales of his products in foreign markets normal and legitimate protection will have been secured to the American manufacturer, for his best customers are farmers and those engaged in occupations which depend directly for profit upon the prosperity of farmers.

THE BEST MARKETS FOR AMERICAN PRODUCTS.

The best foreign markets for American products and commodities are among those nations whose power to buy things and pay for them has been augmented by the use of labor-saving inventions. The principal market, therefore, for American exports is found in the United Kingdom of Great Britain and her colonies, which took during the last fiscal year \$511,751,040 worth of exports from the United States. That is to say, English-speaking people bought 58 per cent of all commodities and products exported from the United States during the fiscal year 1896. Germany, France, Holland, and Belgium purchased during the same period of time \$210,953,054 worth of exports from the United States. That is, the United Kingdom of Great Britain and the nations enumerated purchased 81.9 per cent of the entire export output of the United States during the fiscal year 1896.

Other nations, including the remainder of Europe, Asia, Africa, and South America, took the balance of American exports, which amounted to \$160,902,844 in value and to 18.1 per cent of the entire shipments of this country.

QUESTIONS FOR THE AMERICAN FARMER.

The question for American farmers and all other citizens engaged in gainful occupations to consider is, How can the United States supply the markets of the world with staple food products and necessary articles of manufacture? If the labor cost of a product is governed by the rate of daily wages, how can a dollar's worth of farm products, or of commodities from manufactories in the United States, be sold in foreign parts?

Is not that nation which, like the United States, possesses the greatest power and facilities for producing and manufacturing those exchangeable things which the world demands destined to monopolize the markets of the globe? Do not the most favorable natural conditions for varied and successful agriculture abound in the United States? In what country is there less burden of national taxation? What other people pay so little for the maintenance of a standing army? Who can compete with the American farmer or the American manufacturer in developing the best results of human toil with a minimum of human effort?

EFFECT OF LABOR-SAVING INVENTIONS—WAGES.

In the United States labor-saving inventions are applied in almost every avenue of production. Nowhere else on the globe has agriculture so many improved, useful, and ingenious devices, implements, and machines at its command. Therefore the exports of American farm products must increase; and the sales from those exports, after yielding adequate profits to maintain the farm, will yield also a higher rate of wages to those who do the mechanical and manual work than the wages paid in those nations which are our principal customers. Necessarily the wages paid in the United States—for instance, in the production of wheat and cotton, the great articles of export—are from 50 to 500 per cent higher than they are in those countries with which we compete in selling our cotton and wheat; while in manufactures from the metals the wages paid those who make articles of iron and steel for export are from 25 to 100 per cent higher than the wages paid workers in the same industries by the nations with which we compete.

MILLIONS DEPEND UPON FOREIGN MARKETS.

Under the foregoing conditions, about 1,700,000 laborers on American farms are almost constantly employed in developing agricultural products for exportation.

At the same time, with a rapidly increasing export of manufactured articles from the United States, the number of laborers engaged in mechanical occupations, who must depend for their steady employment upon the demand which the world makes for American goods, is constantly increasing. It is probably quite safe to declare that at least two millions of American workmen, on farms and in factories, subsist almost wholly upon employment based upon foreign demand for American commodities. And in this contest for feeding and furnishing mankind—notwithstanding the fierce competition which meets us all over the globe—American Agriculture, Manufacture, and Commerce are steadily gaining more trade, and thus furnishing an enlarged wages fund, on a Gold basis, out of which many thousands of American laborers and skilled artisans draw their yearly remuneration, and upon which they and their families largely depend for employment and comfort.

J. STERLING MORTON,
Secretary.

NOVEMBER 16, 1896.

Since the original publication of the foregoing report additional information relative to the disposition of the public domain has become available, for which see the Appendix.

EXTERMINATION OF NOXIOUS ANIMALS BY BOUNTIES.

By T. S. Palmer,

First Assistant, Biological Survey, U. S. Department of Agriculture.

The payment of rewards or bounties for killing noxious animals is not a new idea. This method of extermination was adopted by the colonies of Massachusetts and Virginia before the middle of the seventeenth century, and has been continued ever since, but neither the results nor the cost of such legislation seem to be generally known. Bounty laws have been passed by nearly every State and Territory, and in 1895 were still in force in about thirty States and in six of the Canadian provinces. The expenditures have increased in the last decade, and more than $3,000,000 has been spent during the last twenty-five years. Since the burden of the expense falls on the community at large, while the benefit is restricted to a comparatively small class, the question naturally arises as to how far the method has been successful, and whether the results warrant its continuance.

THE DEMAND FOR BOUNTY.

More than a score of animals in the United States are considered sufficiently injurious to require radical measures for their extermination. Wolves, coyotes, panthers, bears, and lynxes are very destructive, but perhaps do not cause greater loss than ground squirrels, pocket gophers, rabbits, and woodchucks. A few birds also, such as blackbirds, crows, English sparrows, hawks, and owls, are sometimes included in the category of noxious species. The most plausible and persistent demands for protection from the depredations of wild animals have come from owners of sheep and cattle, and many of the bounty laws have been enacted ostensibly to encourage sheep raising. No doubt this industry has many claims for this protection, but it may be noted that the most urgent demand for bounties in the West have come, not from the farmers or owners of small flocks, but from cattle and sheep men whose immense herds and flocks are pastured on Government land, and who claim that the cost of protecting their herds and flocks should be borne by the county or State. In some regions the losses on account of wolves and coyotes are so serious as to threaten the success of the sheep industry. It was estimated in

1892 that in New Mexico, where the sheep were valued at $4,556,000, such losses varied from 3 to 7 per cent; in Nebraska the value of sheep was about $2,000,000, while the losses amounted to 5 per cent, or $100,000; and sheep owners in central Texas suffered losses on account of wild animals to the extent of 10 to 25 per cent.[1] Farmers, too, have just cause for complaint. In eastern Washington the grain fields and orchards are damaged every year by ground squirrels to the extent of hundreds of thousands of dollars, and the losses are scarcely less in some parts of California, Montana, and North Dakota, while in most of the Western States orchardists and vineyardists suffer from the depredations of rabbits and pocket gophers.

The value of bounties is not admitted by all, and those who are supposed to be most benefited by them are often the ones who complain most of the failure of the laws and the lack of real protection which they afford. Just previous to the passage of the present bounty law in Iowa a prominent sheep owner of Grinnell stated that it was impossible to raise sheep in some parts of the State on account of the wolves, and he attributed the unsatisfactory conditions to the low rates and unequal bounties.

Any scheme intended to bring about the extermination of a species must fulfill certain conditions before it can prove successful in practice: (1) It must be applied over a wide area practically covering the range of the species, otherwise the animals will increase in the unprotected region; (2) it should be uniform (i. e., the rates should be the same) in all localities; (3) it should provide some inducement for carrying out its provisions; (4) it should be economical, for if expensive, the cost will exceed the losses which it seeks to avert; (5) it should provide so far as possible against fraud or the misappropriation of public funds. In order to see how far bounties have met these requirements, it will be necessary to review briefly the history of this legislation and to note the operation of some of the recent laws.

Under the bounty system a fixed sum is offered for each animal, and the reward is paid to the claimant upon delivery of the skin or scalp. The amount of money which an individual may receive therefore depends entirely on his own efforts or on the condition of the public funds. It is urged in support of this method that the State or county pays only for the animals actually killed, and that it suffers no other expense, as the rewards are drawn from regular funds of the county and are disbursed by county officers oftentimes without additional compensation. It is sometimes claimed that this inducement to capture animals furnishes employment to men and boys who do not desire or can not get other work, and are thus encouraged to labor for the benefit of the community, and that by increasing the rewards the extermination can be hastened whenever necessary. Simple and economical as this method appears theoretically, it has proved extremely

[1] Heath, Special Report on Sheep Industry in the United States, 1892.

unsatisfactory and very costly in practice, and the mere fact that over three hundred laws have been enacted in the United States would seem to show that bounties have not accomplished all that was expected of them.

HISTORY OF BOUNTY LEGISLATION IN THE UNITED STATES.

The first laws providing rewards for the destruction of wild animals seem to have been passed in Massachusetts about 1630 and in Virginia about 1632. Bounty legislation has therefore extended over more than two centuries and a half—a sufficient length of time, it would seem, to test its merits or defects. But so little attention has been paid to the matter that almost every State has been compelled to experiment for itself, instead of profiting by the experience of others, and has learned the limitations of the method only after spending thousands of dollars.

The history of bounty legislation may be conveniently divided into three periods: (1) From 1630 to 1775; (2) from 1776 to 1865; (3) from 1866 to 1896. These three periods are unequal in length (146, 90, and 31 years), but the payments during the last period probably exceed those of the other two combined, although the number of years is only one-eighth as great. This is not due entirely to higher rates in recent years, for the payments in Maine between 1830 and 1865 were almost exactly the same as those from 1866 to 1895.

During the colonial period bounties were confined mainly to wolves, and in Virginia for more than a century and a half the rewards were paid in tobacco, which was the usual medium of exchange in that colony. The general bounties were supplemented by special rewards paid by the counties, and the Indians were encouraged to aid in the work of extermination. In some of the colonies crows, squirrels, and blackbirds caused so much damage that rewards were offered for their scalps, and in South Carolina means were taken to protect the planters from the depredations of rice birds. The necessity for such protection was quaintly expressed in the act of 1695, as follows:

> Whereas the planters of this province do yearly suffer considerable damage by birds and beasts of prey in their stocks and crops, whereby, notwithstanding their continual care, they are impoverished and discouraged, be it enacted * * * that every person or persons who shall kill and destroy the small blackbirds and rice birds shall receive half a royall per dozen, and for crows, jackdaws, and larks, shall receive one royall and a half per dozen.

From 1776 to 1865 numerous laws were passed in the original 13 States, and the bounty system was extended over most of the territory east of the Mississippi River. Most of the rewards were paid for wolves, and the work of extermination, begun in Ohio and Kentucky in 1795, and in Tennessee in 1797, extended gradually westward to Missouri, Iowa, and Nebraska, and even to Washington. As time went

on and the country gradually became settled, attention was paid to getting rid of other animals, such as bears, panthers, wild-cats, and foxes. In New England great numbers of crows were killed, particularly in Maine and New Hampshire, and in the latter State the killing of hawks was encouraged at the expense of the public treasury. With the beginning of the war more important matters claimed the attention of legislators, and in most of the States little thought was given to bounties on wild animals.

Since 1866 bounty laws have been passed in increasing numbers by nearly all the States and Territories. With the development of the West and the increase in cattle and sheep raising, the necessity for exterminating wolves and coyotes has become more apparent. Immense numbers of these animals have been killed in Montana, North Dakota, South Dakota, Wyoming, and Colorado; but they still seem to be very numerous. Several States have also offered premiums for foxes, wild-cats, minks, and even weasels. The success of the sheep men in their warfare against predatory animals encouraged the farmers of the Mississippi Valley and the Great Plains region to demand appropriations from State and county treasuries for killing ground squirrels, gophers, and rabbits. This legislation has proved not only ineffective, but extremely expensive. The experiment has been tried in Minnesota, Montana, California, and North Dakota, and in each case the result has been disastrous to the treasury; in fact, no State thus far has been able to pay a general bounty on ground squirrels and gophers for any length of time.

Bounties on birds, which were by no means uncommon in colonial times, have recently been revived in several States. Since 1875 an unusual interest has been manifested in the extermination of hawks and owls, notwithstanding the fact that it has been demonstrated that most of these birds are actually beneficial instead of injurious. Hawk laws were passed in Delaware, New Hampshire, Pennsylvania, Colorado, Indiana, Ohio, Maryland, Virginia, and West Virginia. The law in New Hampshire was repealed in 1881, after being in force for four years, but was again revived in 1893; the bounty in Colorado remained in force eight years, while the Pennsylvania "scalp act" was enforced only a year and a half, costing the State about $90,000 for birds of prey alone. The extermination of crows was encouraged in New Hampshire from 1881 to 1883, and in Maine from 1889 to 1891. In the latter State 50,707 crows were killed at an expense of a little over $5,000. Illinois and Michigan have turned their attention to the English sparrow. Three acts have been passed in Michigan since 1887, and have cost the State $61,800, while the law in Illinois, enacted in 1891, has involved an expenditure of $55,600. Premiums for birds are perhaps the most pernicious of all bounties. Dr. C. Hart Merriam has estimated that the poultry killed by hawks and owls in Pennsylvania in a year and a half would be worth $1,875.

But every hawk and owl kills at least 1,000 mice in the course of the year, and therefore, estimating the damage done by a mouse at 2 cents, each hawk and owl would save the farmer $20 per annum. In other words, the expenditure of $90,000 caused the destruction of birds worth $3,857,130 to save a possible loss of $1,875 to the poultry industry.[1] Although the crow is almost universally condemned, it is by no means certain that it is responsible for all the damage that is usually attributed to it. In fact, recent investigations by the Department of Agriculture show that the crow is rather more beneficial than injurious. The English sparrow is recognized everywhere as one of the greatest pests which could have been introduced into this country, but the offering of rewards for its destruction encourages the killing of native birds which are indistinguishable from it to the unpracticed eye of the officer who pays the bounty.

EXPENSE OF THE BOUNTY SYSTEM.

In 1895 laws providing bounties on wild animals were in force in about thirty States of the Union, but with the exception of New Mexico and Texas practically no rewards were offered in any of the States lying south of latitude 37°. North of this line bounty laws were in force in all the States except Massachusetts, Connecticut, Delaware, Indiana, and possibly West Virginia. In some cases the expenditures were small, but in Minnesota, Montana, and Wyoming the expense was heavy.

It is extremely difficult to obtain accurate statistics regarding the cost of this legislation, owing to the fact that in some cases the rewards are paid from the State treasury, in others by counties. State bounties are usually included in the reports of the treasurer or auditor, but reports of county officers are seldom published in detail, and it is necessary to secure the data from the original records. When a change occurs in the office of county clerk or treasurer, the new incumbent frequently finds difficulty in unraveling the old accounts, and he may be entirely ignorant of an expenditure of thousands of dollars under his predecessor. Old records are sometimes inaccessible and sometimes burned, so that it is practically impossible to obtain returns for a series of years.

Reports of bounty payments during the last quarter of a century have been collected in detail from twenty-nine States. As shown in the table following, nearly $2,400,000 has been spent, but the returns are more or less incomplete from all the States except Maine, Michigan, Montana, Minnesota, New York, and Wisconsin. No attempt has been made to secure statistics from twelve other States in which relatively small amounts have been paid, and it is safe to say that the total expenditures aggregate more than $3,000,000.

[1] Report Commissioner of Agriculture, 1886, p. 228.

Bounties paid on noxious animals and birds from 1871 to 1895.

State or Territory.	Bounty paid.[1]	Total amount.	State or Territory.	Bounty paid.[1]	Total amount.
Arizona	1887–1895	[2] $10,000	New Hampshire	1874–1895	$56,728
California	1886–1895	210,345	New Mexico	1891–1895	6,645
Colorado	1889–1895	93,827	New York	1871–1895	41,330
Idaho	1878–1895	46,591	North Dakota	1886–1895	79,565
Illinois	1877–1895	89,566	Oregon	1885–1895	67,743
Indiana	1875–1895	22,600	Pennsylvania	1885–1887	[2] 150,000
Iowa	1871–1895	156,484	Rhode Island	1893–1895	3,995
Kansas	1875–1895	126,955	South Dakota	1887–1895	40,777
Maine	1871–1895	49,500	Texas	1891–1892	50,000
Michigan	1871–1895	80,774	Utah	1888–1895	3,129
Minnesota	1876–1895	303,228	Vermont	1881–1895	32,089
Missouri	1879–1895	[2] 36,000	Washington	1882–1895	53,826
Montana	1883–1895	175,367	Wisconsin	1871–1895	[2] 313,500
Nebraska	1881–1895	28,148	Wyoming	1885–1896[3]	31,803
Nevada	1885–1895	26,831	Total		2,387,361

[1] Short periods show the years for which returns are available and do not necessarily include the whole time bounties were in force, except in Arizona, Idaho, Montana, Nevada, New Mexico, Rhode Island, and Utah.
[2] Estimated.
[3] To March 31.

The cost of a law depends of course on the length of time that it remains in force; but it is probable that any act which offers a sufficiently high premium to insure its enforcement will involve an expenditure of from \$5,000 to \$20,000 per annum. In the following table are given six of the most noted bounty laws passed during the last decade, and it will be seen that while all but one remained in force less than two years, the expenditures varied from \$50,000 to nearly \$200,000. Such an expense as this could not long be maintained by any State, and, with the exception of the Illinois sparrow act and the Montana bounty law of 1895, all the laws have been repealed.

Payments under six recent bounty laws.

State.	Act.	In force.[1]	Total bounty.	Average per month.
California	Coyote act	18 months: Mar. 31, 1891–Sept. 30, 1892.	$187,485	$10,416
Illinois	Sparrow bounty act	15 months: Dec. 1, 1891–Feb. 29, 1896.	55,661	3,710
Montana	Ground squirrel act	6 months: Mar. 5, 1887–Sept. 13, 1887.	54,578	9,096
Do	Wolf bounty law	14 months: Feb. 26, 1895–Apr. 21, 1896.	89,871	6,419
Pennsylvania	Scalp act	23 months: June 23, 1885–May 13, 1887.	[2] 150,000	6,521
Texas	Protection of farmers	16 months: Apr., 1891–Aug. 31, 1892.	50,000	3,125

[1] The time represents the period during which payments were actually made; for example, the California coyote law remained in force until January, 1895, and the claims amounted to nearly \$400,000, but payments ceased on September 30, 1892, and only \$187,485 was actually paid. The Illinois sparrow law is in force only during December, January, and February.
[2] Estimated.

OBJECTIONS TO THE BOUNTY SYSTEM.

The difficulties encountered in carrying out the provisions of bounty laws are so great as to give rise to serious objections to such legislation. No rewards for killing wild animals are paid by the General Government in this country, for each State has jurisdiction over its noxious as well as its useful birds and mammals, and must make its own laws for each species.

Bounty laws may be divided into three main groups: (1) Acts providing for the payment of premiums from the State treasury; (2) acts permitting rewards to be paid from county treasuries; (3) local acts maintained at the expense of township treasuries. Some States have found county bounties most effective; others have relied entirely on State bounties. In Michigan all three kinds are in operation; bounties for wolves are paid by the State, rewards for English sparrows from the county treasuries, and premiums on woodchucks, hawks, crows, and moles by townships. Each method has its advantages, and each its defects. The advantages claimed for the State bounty are greater uniformity and efficiency; if the bounty is paid by counties, its maintenance depends entirely on the interest manifested by each county, and the law is seldom enforced in all. A more serious defect lies in the varying rates which are sure to be paid and the consequent danger that scalps will be carried where the highest rate is paid and thus increase the expense in counties which offer high premiums. The objection of inequality may be urged even more strongly against township bounties. Trouble is sometimes caused in States which have large forest or Indian reservations where animals can increase, as the adjoining counties are almost sure to receive scalps taken on the reservations, and are thus compelled to bear an expense which does not belong to them.

Considerable difficulty is sometimes experienced in raising sufficient funds for paying rewards. In some States the premiums are paid from the general fund without limitation; in others the bounty law carries a specific appropriation. The latter method has been adopted in Colorado, Minnesota, Montana, New Mexico, and Wyoming, but payments have not always been kept within the limit, and in case of an excess, a deficiency appropriation is necessary. To obviate this, a clause was inserted in the Texas law of 1891 providing that the act should become inoperative as soon as the appropriation of $50,000 was expended. This had the desired effect of limiting the payments, but it practically repealed the law, as the fund became exhausted some months before the next meeting of the legislature. Payments from the general fund are open to the objection that the counties which contribute least toward the expenses of the State are usually the ones which draw most heavily for bounties. As such a burden is not only unequal, but the benefit which it confers is restricted to a comparatively small proportion of the taxpayers, some States require

a special tax for the bounty fund. In Montana, where bounties benefit the cattle and sheep men almost exclusively, the law of 1895 authorized a special tax of one and one-half mills per dollar on the assessed valuation of all horses, cattle, and sheep, in addition to the regular proportion of taxes set aside as a State bounty fund. The same principle has been adopted in Ohio and some of the counties of Virginia where the rewards are paid from a dog tax or some other special fund.

One of the most difficult matters to regulate in connection with bounty legislation is the rate allowed for scalps. If the reward is too low, there is no inducement to destroy noxious animals, and the law becomes practically inoperative. This was the case with the Montana act of 1879, which apparently failed entirely, as the reports of the county treasurers fail to show the expenditure of a single dollar for bounties during the four years the law remained on the statute books. If, on the other hand, the rate is too high, the results are most disastrous. No treasury can stand the drain caused by a high bounty for any length of time. The coyote act of California went into effect March 31, 1891, but payments were stopped September 30, 1892, after $187,485 had been expended. The prairie-dog and squirrel bounty law of Montana, passed in 1887, remained in force but six months before the funds in the treasury were exhausted. The coyote bounty of 1892 not only exhausted the regular appropriation of $12,000, but necessitated a deficiency appropriation of $17,343 to pay the claims which were presented against the State. The Colorado bounties of 1889 involved such a heavy outlay that other appropriations from the same fund could not be paid, and the law was finally declared unconstitutional by the supreme court of the State.

Inequality in the rates offered in adjoining States or counties is almost as bad as a high premium, since scalps are likely to be taken from localities where the rewards are low to the nearest county which pays a high premium, and which is thus compelled to pay for animals which do not belong to it. In 1895 bounties on wolves and coyotes varied from $1.50 to $5 in the Black Hills region of South Dakota, while the rewards were $2 in North Dakota, $3 in Montana and Wyoming, and $5 in Iowa. Not only were scalps sent from one county to another, but rewards were claimed in Iowa for coyotes taken in South Dakota. While the coyote law was in force in California the premium was $5, but in Nevada only 50 cents was allowed. Nevada reported the destruction of comparatively few coyotes, but thousands of scalps were presented for payment in California, and it was notorious that many were imported from neighboring States, and even from Lower California.

Not less important than the rate is the proof (which must be submitted before the bounty is paid) that the animal has been killed as claimed. Many States require the scalps, including the ears, to be

produced as evidence, and it is important that these scalps should be sufficient to identify the animals without question in order to leave no chance for fraud. It will suffice merely to mention a few of the ways in which rewards have been obtained fraudulently. Skins of dogs or other domesticated animals have been turned in as scalps of wolves or coyotes, and in the case of small species, when the heads have been accepted in one county and the tails demanded in another, the bounty has been collected on the same animals twice. One of the counties in North Dakota, which paid considerable sums for ground squirrels, first required the heads as "scalps;" then the tails; a year or two afterwards all four feet, and finally withdrew the bounty altogether. Ignorance on the part of the bounty official sometimes results in the payment of premiums for species to which the law was never intended to apply. Dr. B. H. Warren, who has made a careful study of the "scalp act" of Pennsylvania, states that the heads of domesticated fowls, partridges, pheasants, cuckoos, butcher birds, and even night hawks were accepted in some counties as those of hawks and owls.

Such cases as these emphasize the importance of protecting the State against imposition. If the bounty is paid by county officers, it should be limited to species which are readily recognizable. New Hampshire offered rewards for hawks supposed to be destructive to poultry and other birds, and endeavored to meet the difficulty of identification by requiring the selectmen of the town to certify that the hawks were injurious before the bounties were paid, but, as the State treasurer remarked in a recent report, it is not likely that boards of selectmen were elected on account of their proficiency in ornithology! British Columbia, which claims almost complete immunity from fraudulent payments, restricts the premiums to wolves, coyotes, and panthers, and requires the skull of the animal to be presented at the Provincial Museum, where it is examined by the curator before the bounty is paid. In some States the law demands the entire skin to be brought in for examination; such skins are canceled to prevent them from being presented a second time, and then returned to the owner. In practice this method is likely to increase rather than diminish fraud, for the reason that skins are not canceled uniformly. In Vermont wolf skins are marked by punching two holes a quarter of an inch in diameter in the ear; in Wyoming a single hole half an inch in diameter is punched in the ear, or sometimes a small hole in the foot; in Utah the skins are canceled by cutting the letters B P an inch and a half in length in the neck. Thus, Wyoming skins, which had been canceled by a hole in the foot, might be presented in Utah if the feet were removed, and the heads could then be cut off and sent to a State which required only the scalps. It is true the applicant is usually required to state under oath where the animal was killed, and in Montana he must also file affidavits of two resident taxpayers of

the county who are acquainted with him and who believe the animal to have been killed as claimed. The Montana law of 1895 declares the alteration or counterfeiting of scalp certificates to be forgery; swearing falsely to affidavits, perjury, punishable by imprisonment from one to ten years, while patching or presenting punched skins is defined as a misdemeanor punishable by a fine not exceeding $500 or imprisonment for not more than three months. With all these precautions against fraud no reference is made to raising animals for bounty, a matter which has sometimes given rise to serious trouble, but which is expressly mentioned in the laws of only a few States. Cases have been recorded in which eggs of hawks and owls were taken from the nest and hatched under hens in order to secure premiums on the young birds. It was said to be more profitable in Iowa a few years ago to raise coyotes for the bounty than to raise sheep, and Kentucky and New Mexico, recognizing the possibility of breeding wolves, required affidavits showing that the animals had not been raised for the rewards.

WHAT HAVE BOUNTIES ACCOMPLISHED?

Advocates of the bounty system seem to think that almost any species can be exterminated in a short time if the premiums are only high enough. Extermination, however, is not a question of months, but of years; and it is a mistake to suppose that it can be accomplished rapidly except under extraordinary circumstances, as in the case of the buffalo and the fur seal. Theoretically, a bounty should be high enough to insure the destruction of at least a majority of the individuals during the first season, but it has already been shown that scarcely a single State has been able to maintain a high rate for more than a few months, and it is evident that the higher the rate the greater the danger of fraud. Although Virginia has encouraged the killing of wolves almost from the first settlement of the colony, and has sometimes paid as high as $25 apiece for their scalps, wolves were not exterminated until about the middle of this century or until the rewards had been in force for more than two hundred years. Nor did they become extinct in England until the beginning of the sixteenth century, although efforts toward their extermination had been begun in the reign of King Edgar (959–975). France, which has maintained bounties on these animals for more than a century, found it necessary to increase the rewards to $30 and $40 in 1882, and in twelve years expended no less than $115,000 for nearly 8,000 wolves.

Attention has already been called to some of the requisites of a successful method of extermination, and particularly to the fact that rewards should be paid wherever the animal is found. The bounty on wolves and coyotes most nearly satisfies these conditions, as it has been more generally paid than that on other species. Every State and Territory west of the Mississippi, except Arkansas and the Indian

Territory, has enacted laws for the destruction of these animals, but the results have not been altogether satisfactory, and the rates have frequently been changed. High premiums have been tried in California, Montana, and Texas, and found impracticable. Each of these States offered $5 for coyote scalps for some time, and the outlay aggregated hundreds of thousands of dollars. Iowa and Minnesota are the only Western States which now pay more than $3 per scalp, and in Iowa the rate on young wolves is $2. It has, moreover, been impossible to secure the active cooperation of all the States, and where the bounty depends on the order of the board of county supervisors it may, as in the case of Idaho, become inoperative.

The larger animals are gradually becoming rare, particularly in the East, but it can not be said that bounties have brought about the extermination of a single species in any State. Wolves are now almost extinct east of the Mississippi River except in Florida and a few other States, but their present rarity is due rather to the settlement of the country than to the number killed for rewards. On the Great Plains, where civilization has not yet encroached on their domain to any great extent, they have not decreased rapidly or even perceptibly in some places, notwithstanding the high rewards for their scalps. It is perhaps safe to say that coyotes have increased in California in the four years which have elapsed since bounties were withdrawn, and that the effects of the law of 1891 are hardly perceptible.

Maine has encouraged the killing of bears ever since 1830, but the returns of the last five years do not show any decided decrease in the scalps presented for bounty. New Hampshire has been paying for bears about as long as Maine, but in 1894 the State treasurer called attention to the large number reported by four or five of the towns, and added that should the other 234 towns "be equally successful in breeding wild animals for the State market, in proportion to their tax levy, it would require a State tax levy of nearly two million dollars to pay the bounty claims." Even New York withdrew the rewards on bears in 1895, not because they had become unnecessary, but because the number of animals killed increased steadily each year.

If this is the result when bounties on large animals are paid by many States, what can be expected in the case of squirrels, gophers, and rabbits, which are immensely more numerous than wolves or bears, and against which legislation has been at best extremely desultory? Ada County, Idaho, waged war on rabbits for seventeen years, but after destroying more than a million abandoned the bounty method. Iowa, Minnesota, and South Dakota have tried to rid their lands of pocket gophers and ground squirrels, but the effect of the laws was far more evident on the county treasuries than on the

animals. The destruction of a million ground squirrels in one county in Washington did not exterminate the species, and Montana, in killing 712,192 squirrels and 189,678 prairie dogs in 1887, probably made little impression on the total number in the State. In the early seventies California authorized the levying of special taxes at high rates for killing gophers and ground squirrels, and later enacted laws providing for the division of certain counties into squirrel districts in charge of inspectors, and required owners to kill the squirrels on their land or pay for having them destroyed by the inspectors. Systematic efforts were made to exterminate these pests, but the attempt was abandoned on account of the expense. So little effect had these laws that to-day squirrels are practically as abundant as ever, and not long ago an inquiry was received from a resident in one of the counties which was most active in the work of extermination asking whether anything had ever been done to check the increase of the Californian ground squirrel! Nearly three million sparrows have been destroyed in Illinois during the last five years, and probably as many, if not more, have been killed in Michigan since 1887, but the laws have accomplished so little that some doubt exists as to whether the birds have perceptibly diminished or not. Some ornithologists in these States assert that the decrease is quite noticeable, while others acknowledge that the bounties have had little if any effect.

On the island of Bermuda, which has an area of less than 20 square miles, an attempt was made to exterminate the English sparrow only ten years after the species had been introduced; but after two years, the experiment, which had cost more than $2,500, was abandoned as impracticable. In India, where the loss of life and of domesticated animals on account of the depredations of wild animals and snakes is enormous, bounties are paid in most of the provinces. The official returns for 1893 showed that 2,828 people and 85,131 head of cattle had been destroyed by animals, while 21,213 persons and 5,122 head of cattle were said to have been killed by snakes. In this year bounties to the amount of 117,448 rupees (nominally $58,724) were paid for the killing of 15,308 wild animals and 117,120 snakes. Although these expenditures have been maintained for twenty years, the number of animals annually killed shows no perceptible decrease, and it is impossible to estimate what the extermination will finally cost the Government. But if bounties have failed to accomplish the actual extermination of any species, there can be no doubt that they have secured the destruction of large numbers of noxious animals, and have done some good in checking the increase of such species as wolves and coyotes. If premiums are paid in several States, do not involve too great expense, and can only be maintained long enough, they will do much toward the accomplishment of the desired end, and may be regarded as a legitimate expenditure of public funds.

SUBSTITUTES FOR BOUNTIES.

The unsatisfactory results attained by the direct payment of rewards from public funds long ago led to the attempt to gain the same end by other means. In colonial times the Indians were encouraged to kill wolves and other animals, and the planters were often required to destroy a certain number of blackbirds, crows, or squirrels each year under penalty of fine. Scalps of crows, squirrels, and even wild-cats were received in lieu of taxes, but as this method had some disadvantages in practice the scalp certificates issued by county officials were accepted in payment of taxes.

Competitive hunts and prizes offered by gun clubs sometimes cause the killing of a surprising number of birds and animals. In Ohio a few years ago nearly a thousand sparrows were killed in one hunt, and the Sparrow Club of Stratford-on-Avon, England, reported that 19,000 sparrows were destroyed during the year 1887. The Virginia Field Sports Association distributed $100 in prizes for the killing of nearly 1,000 hawks in 1888; this was less than one-fifth what it would cost the State for bounties. Prizes offered by the Luzerne County Sportsmen's Club of Pennsylvania in 1895 secured the destruction of 378 animals, 42 hawks, and 4 owls. In the rabbit drives of California, which are sometimes paid for from public funds, as many as 20,000 jack rabbits have been killed in a day. The great danger in the case of prizes is that useful and injurious species will be killed indiscriminately, but under proper restrictions this could be avoided, and clubs might do much more toward the extermination of animals than is now accomplished by bounties.

Another expedient which has been resorted to, particularly in North Dakota, South Dakota, Washington, and Manitoba, is the free distribution of strychnine or other poison. The results seem to be quite satisfactory, and it is said that more animals are destroyed at much less cost than under the bounty system. Reference has already been made to the ground-squirrel legislation of California which promised so much but accomplished so little on account of the expense, notwithstanding the fact that everything was done to render the laws effective.

SUMMARY.

(1) Bounty legislation has existed in the United States for more than two centuries and a half, and has been thoroughly tested in most of the States and Territories.

(2) Rewards have been paid (*a*) on large animals, such as wolves, coyotes, bears, and panthers; (*b*) on small mammals, particularly gophers, ground squirrels, and rabbits; (*c*) on a few birds, such as crows, English sparrows, hawks, and owls.

(3) This legislation has probably involved an expenditure of over $3,000,000 in the last quarter of a century, and the expense seems to be

increasing instead of decreasing. Single laws have caused an outlay of nearly $200,000 in less than two years, and it is safe to say that any act which carries a sufficiently high reward to insure its operation will cost from $5,000 to $20,000 per annum.

(4) Objections to the bounty system may be grouped under four main heads: (*a*) Expense, which is usually out of all proportion to the benefit gained, and may be greater than the county or State can afford; (*b*) impossibility of maintaining bounties in all parts of an animal's range for any length of time; (*c*) impossibility of maintaining equal rates in all States; (*d*) impossibility of preventing payments for animals imported from other States, for counterfeit scalps, or for animals raised especially for the bounty. These objections have never been satisfactorily overcome, and most laws have failed through one or another of these causes.

(5) Bounties have not resulted in the extermination of a single species in the United States, and have failed even in the island of Bermuda, which has an area of less than 20 square miles.

(6) Rewards for wolves, coyotes, and panthers are now so generally paid as to check the increase of these species to some extent, but premiums on ground squirrels, gophers, and other small mammals have accomplished little or nothing, and bounties on birds may do great harm by encouraging the killing of useful species through ignorance.

(7) Extermination of noxious animals is usually slow and can be accomplished more effectively and economically through the efforts of individual land owners than by the lavish expenditure of public funds.

THE USE OF STEAM APPARATUS FOR SPRAYING.

By L. O. Howard, Ph. D.,
Entomologist, U. S. Department of Agriculture.

GENERAL REMARKS.

In the article on "The shade-tree insect problem in the eastern United States," published in the Yearbook of the Department of Agriculture for 1895 (pp. 361–394), the writer urged the adoption of steam spraying apparatus in cities and towns where shade trees suffer especially from the attacks of insects, and more particularly where the shade trees are very large. A brief description in general terms of the necessary points to be considered in the construction of such an apparatus was also given. As a partial result, it is to be hoped, of this recommendation, but also independently, from the obvious necessities of the case, a number of steam machines have been adapted or constructed for this purpose in northeastern cities during the season of 1896, and all have been operated with a considerable degree of success.

The adoption of steam-power spraying has been a necessary and expected outgrowth of the remarkable extension in the use of hand spraying machines during the past ten years. At the time when the investigation of the cotton caterpillar of the South was begun, just before 1880, practically no spraying machines were on the market. There were one or two bucket pumps, which, however, were not especially designed for work against insects, and one or two cumbrous knapsack apparatuses for use against the Colorado potato beetle had been devised. The investigation of the cotton caterpillar resulted in the invention, mainly by the late Dr. W. S. Barnard, working under the direction of Dr. Riley, of a number of machines for field distribution of liquid poisons, and above all in the production of the "Eddy-chamber," or cyclone, system of nozzles, which has since become so prominent in insecticide and fungicide work. The discovery at a somewhat later date of the value of liquid applications as fungicides with vineyard work brought about the invention and manufacture of a serviceable series of knapsack pumps, and the almost simultaneous discovery of the applicability of liquid poisons as a remedy against the codling moth and plum curculio in apple and peach orchards started the construction of hand spraying apparatuses on a larger scale and mounted upon wheels for orchard work. A still later outgrowth in this line of work is the adoption, although as

yet to a slight extent, of horsepower attachments, bringing about a spray through the slow progress of the horse through the orchard

MACHINES FOR ORCHARD SPRAYING.

Probably the first attempt with the use of steam as a motive power for the orchard-spraying machine was made in California. The writer is informed by Mr. Alexander Craw, quarantine officer and entomologist to the State board of horticulture of California, that in the early eighties Messrs. Wolfskill and Goodwin, of Los Angeles, each purchased steam boilers and pumps for spraying their orange and lemon groves, the work at that time being directed mainly against the white or fluted scale (*Icerya purchasi*), afterwards nearly exterminated by the introduction of the Australian ladybird (*Vedalia cardinalis*),

FIG. 1.—Hand apparatus used by J. W. Wolfskill at Los Angeles, Cal.

and against the black scale (*Lecanium oleæ*). After thoroughly trying the machine, Mr. Wolfskill abandoned it and went back to the force pumps, as one man (the one that drove the horse) could pump for from one to four lines of hose and shut off the pressure in any line not at the time being used. Mr. Goodwin used his machine for two seasons and then abandoned it for the same reasons. Mr. Craw is not certain as to the exact date of the construction of these machines, but thinks that it was probably 1881 or 1882, since Mr. Wolfskill proposed to name his machine "Tomocera," after the principal chalcidid parasite of the black scale, first described by the writer in 1880. The main difficulty found with the steam machines was in regulating the force. As long as there was an abundant discharge, the pump would work all right, but it was found to be most difficult to shut off or reduce the nozzles to a very fine spray. This

perhaps could have been overcome with a "governor" or fly wheel, to steady the stroke, but there was, as previously stated, no saving of labor, since with the best hand force pumps the work of pumping was not very hard.

The hand-pump spraying outfit adopted by Mr. Wolfskill after he abandoned his steam spraying machine was illustrated (Pl. V, Report of the Entomologist) in the Annual Report of the Department of Agriculture for 1886. We have been unable to secure an illustration of the abandoned machine, but reproduce (fig. 1) the figure of the hand-power substitute, which is interesting from several standpoints, perhaps particularly on account of the ingenious wheel ladders adopted for use on old orange trees, which are obviously impossible to climb. This arrangement has since come into more or less general use for other purposes.

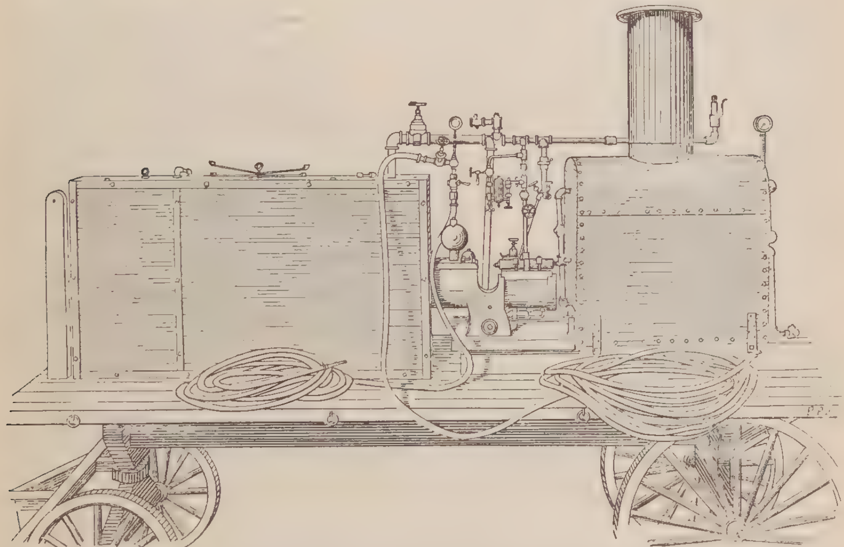

FIG. 2.—Side view of steam apparatus constructed by Stephen Hoyt's Sons, New Canaan, Conn.

The difficulties encountered by Messrs. Wolfskill and Goodwin may have been anticipated by others to such a degree that other experiments in this line were not soon made, or, what is more probable, the use of hand apparatus was found so satisfactory that the necessity for the use of steam power was not apparent. At all events, no experiments in this line have come to our attention down to 1894. In this year Stephen Hoyt's Sons, of New Canaan, Conn., had an apparatus constructed for use on their own estate, where fruit and ornamental trees and vines and plants of a number of different varieties are grown.[1] Under date of August 1 these gentlemen wrote that the

[1] This is the machine shown by Mr. Lodeman in his book on The Spraying of Plants, Macmillan & Co., 1896, p. 194, as "the first successful spraying outfit using steam power."

machine "is still found to be very useful, and it is particularly liked on account of the ease and rapidity of operation, the pump being capable of throwing a good stream over the tallest trees." The details of this apparatus were given in the Nineteenth Annual Report of the Connecticut Agricultural Experiment Station, 1895 (pp. 210–213). The facts concerning the machine, as communicated by Messrs. Hoyt, are as follows:

* * * The boiler was made by Charles W. Foster, in New Haven, and will generate steam sufficient to produce five or six horsepower at a pressure of 100 pounds. The cost was $200. The pumps were made by the Marsh Steam Pump Company, Battle Creek, Mich. We got two pumps, size BB, and intended to run them both for spraying. I had one arranged to feed the boiler and to spray also, but found this did not work satisfactorily, so bought another, two sizes larger (size D), using the smaller pump for boiler feed only. The BB size is quoted at $50, less 50 per cent. This is too large for a feed pump to a boiler of this capacity,

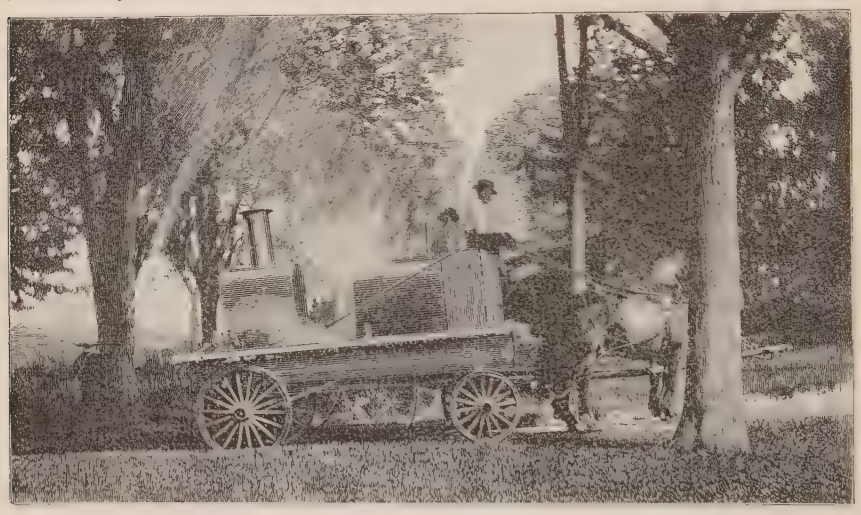

FIG. 3.—Perspective view of steam apparatus constructed by Stephen Hoyt's Sons, New Canaan, Conn., in operation.

and did we not have it, would have bought the smaller size, which is quoted at $30, less 50 per cent.

Our 300-gallon tank was made by George F. Johnson, New Canaan, Conn., and is partitioned off to hold 75 gallons of water to feed the boiler, and 225 gallons of mixture for spraying. This tank was bolted and ironed all through, and cost $40. Our hose, from the Mineralized Rubber Company, was three-fourths inch; but we advise getting one-half inch hose, as the strain is not so great, nor is it so heavy to handle. We used two lines of hose, each 100 feet long. The McGowan nozzle does very good work, and is quite economical with the solution. We also found the Daisy nozzle, made in New Haven, excellent for tree spraying.

Although our boiler uses coal or wood for fuel, we bought it partly for another purpose, and would advise for spraying simply to use a boiler heated by oil, as much more convenient. For a boiler feed-pump would suggest the Marsh, size B, and for spraying, a duplex high-service pump, or one that would give a pressure of at least 150 pounds, such as are made by Worthington, Dean, Knowles, or Snow. The total cost of an outfit would average from $275 to $375, according to size.

Illustrations of this machine are given in figs. 2 and 3.

Perhaps the next experimental steam apparatus for orchard work was built by W. R. Gunnis, of San Diego, Cal. This is the machine which was briefly described in Insect Life (Vol. VII, p. 413), under the caption "Spraying on a large scale." The machine was probably constructed a little later than that of Messrs. Hoyt, but during the same year (1894). It was designed by Mr. Gunnis's son, R. H. Gunnis, and we were informed in August, 1896, that it was at that time the only practical power sprayer in operation in California, except an exact copy of it built by the Union Gas Engine Company, of San Francisco (now in use at Riverside by Mr. Felix Havens), from drawings taken from this machine in its unimproved state while at work in Santa Barbara, in 1895. Mr. Marlatt, however, visiting California in November, found an admirable machine at work at the Las Fuentos ranch, Santa Barbara, under the direction of Mr. F. Kahler, copied in

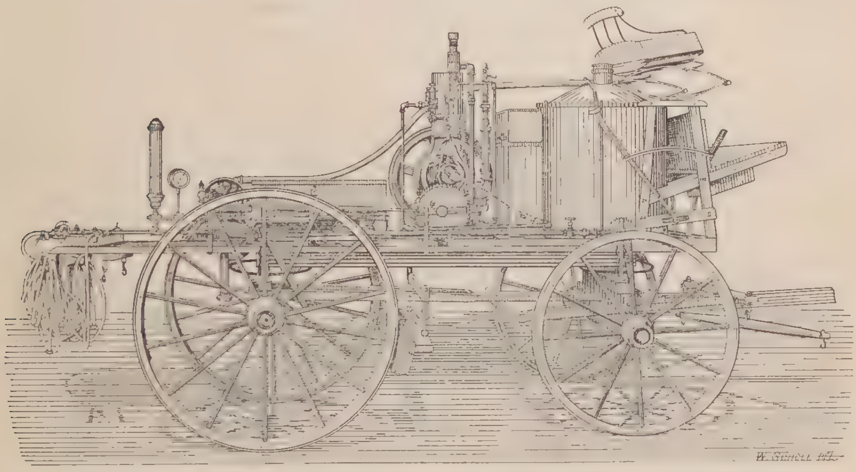

FIG. 4. Right-hand side of steam spraying machine constructed by W. R. Gunnis, San Diego, Cal.

the main from the Gunnis machine. We have received excellent photographs of this machine in operation through the kindness of Mr. Kahler, but unfortunately too late for reproduction.

The details of the Gunnis machine are as follows:

The pump for delivering spray material is of horizontal, double-cylinder, plunger type, capable of working against a pressure of 250 pounds to the square inch, and is operated by a 1-horsepower gas engine. A large tank of 100 gallons capacity contains spray fluid, a small square tank contains gasoline sufficient to run the engine one or two days, and the other tank contains water, which is circulated by a small pump around the cylinder of the engine, thence through a coil inside of the main tank, where it is cooled, then back into its own tank.

In the rear of the pump is an air chamber and a pressure gauge, and at the extreme end of the platform are connections with stopcocks for four or more lines of hose. Forward from the air chamber runs an overflow pipe into the supply tank, having in it an adjustable relief valve, which maintains a normal pressure when some of the spray nozzles are shut off. The overflow is delivered through two nozzles set at an angle, thus keeping the mixture continually agitated.

In order to obviate frequent stoppage for the purpose of refilling the tank, the machine is provided with a tender—a 50-gallon tank hung between low, broad wheels and drawn by one horse.

On the left side of the machine is shown a rotary pump driven by a belt from the engine, running over a friction clutch pulley, the discharge pipe of this pump being carried into the top of the main tank and the suction extending below the bed of the wagon.

The spray material is mixed in the tender, which is driven alongside the machine, and connection made by a length of suction hose to the rotary pump; the pump is thrown into gear, and in two minutes the 50 gallons of mixture is transferred to the main tank without interfering in any way with the work of the sprayers.

The spray nozzles are placed on the ends of extension rods of one-eighth or one-fourth inch pipe covered with bamboo, each rod having a globe valve at its hose end.

The usual crew consists of six—four sprayers, a driver, and a boy to drive the tender. In ordinary work two rows of trees are sprayed at a time, two men to a tree, but if the trees are very large eight sprayers may operate economically.

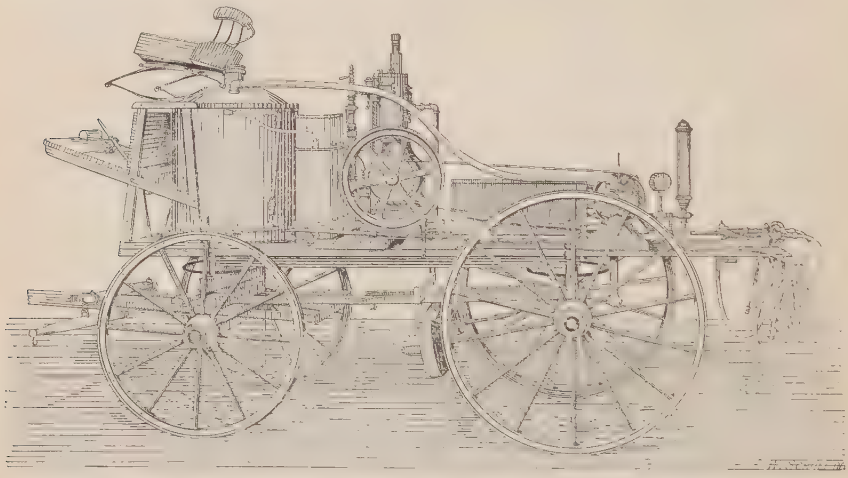

FIG. 5.—Left-hand side of steam spraying machine constructed by W. R. Gunnis, San Diego, Cal.

Mr. Gunnis writes that this machine has proved to be an entire success, both for efficiency and economy, and some very large orchards have been treated with it where a hand pump would have been entirely useless.

Both sides of the Gunnis apparatus are shown in figs. 4 and 5.

It will be observed that according to Mr. Gunnis the machine built by the Union Gas Engine Company, of San Francisco, was designed from the unperfected Gunnis machine of 1895. The Pacific Rural Press, June 13, 1896, gives a figure of what is practically the same machine, which we have reproduced (fig. 6), with the statement that it is a gasoline spraying plant recently constructed by the Union Gas Engine Company for the Las Fuentos ranch of Santa Barbara. The machine is said to be designed by Arthur Bell, consulting engineer of the Alcatraz Asphalt Company. It is described as follows:

The plant consists of a 1-horsepower Union gasoline engine, to which is connected a special double-acting pump, so arranged as to draw from the solution tank and

force into a vertical receiver at a pressure of 250 pounds per square inch. At the receiver is a by-pass, so arranged that the extra solution which is not immediately carried off through the spraying nozzles is returned under pressure to the solution tank, and keeps the same constantly agitated. The circulating water for the engine is carried in the lower square tank, and after passing around the cylinder it is returned through a coil in the solution tank to its starting point, being in this way used over and over again. The small oblong tank on top of the water tank contains the small amount of gasoline necessary to run the plant for a day.

The whole is set on a wooden base, covered with a galvanized sheet-iron pan, and is of a suitable size to go on an ordinary wagon running gear. The hose connections, of which there are four, are at the rear end of the wagon, thus being in a convenient position for operation.

The compound tank has a capacity of 100 gallons, the weight of the entire outfit being about 750 pounds, and is put upon the market, complete, for $350. The illustration represents the first one built, which is now in use and giving satisfaction.

The Shipman Engine Manufacturing Company, of Rochester, N. Y., which has for a long time been building engine devices for farmers for use in cutting and grinding feed, for sawing wood, for the dairy, and

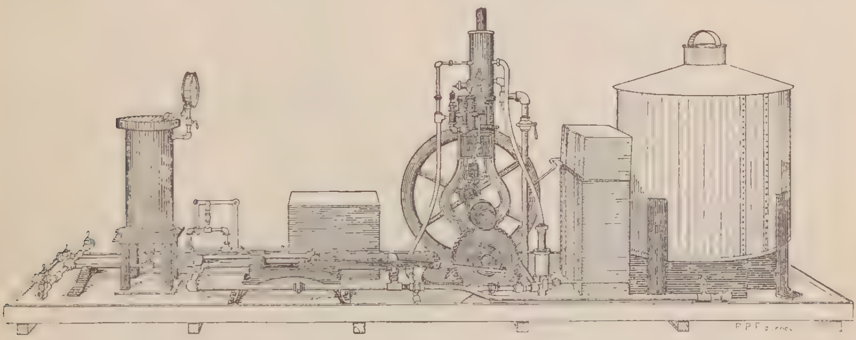

FIG. 6.—Details of steam spraying machine constructed by Union Gas Engine Company, San Francisco, Cal., on the lines of the Gunnis machine.

for other purposes about the farm, built during the winter of 1895–96, a spraying engine which was placed with the Massachusetts Agricultural Experiment Station, at Amherst. The apparatus consisted of the Shipman spray pump connected with a 150-gallon tank mounted on springs on a low-wheeled truck. The machine was used by Prof. S. T. Maynard, of the Agricultural Experiment Station at Amherst, with paris green, bordeaux mixture, and kerosene emulsion. No trouble was experienced in reaching the tops of trees with the spray, and the apparatus was considered by Professor Maynard to be successful. The greatest disadvantage was found to be the loosening of the joints of piping, owing to the racking of the wagon. This, however, is a matter which could be easily remedied. Professor Maynard found that the great advantage of the machine over the hand or geared pump consisted in the fact that the full power can be applied quickly and shut off quickly, and can be run whether the tank is moving or stationary. No difficulty was found in throwing two streams continuously and in covering both sides of a row of apple trees as fast as the

team moved among them. We have no illustration of this machine. The engine-manufacturing company advise using an automatic oil-burning boiler, although the engine may be fitted with a light improved coal or wood burning boiler with a spray pump and special pattern of steam pump, designed solely for the purpose, having all parts with which the liquid comes in contact made of phosphor-bronze to avoid corrosion. No. 1 has a capacity of 8,000 or 10,000 gallons per day of ten hours, and No. 2 has a capacity of 20,000 to 25,000 gallons for the same time. Running constantly at ordinary capacity, No. 1 will consume about 4 gallons and No. 2 about 8 gallons of oil per day. The price of No. 1, mounted, including a 200-gallon fluid tank, tool chest, and agitating device, without hose and nozzles, is $260. No. 2, mounted the same way, is $400.

FIG. 7.—Steam spraying machine used by T. B. Wilson, Hall's Corners, N. Y.

The machines just described are the only ones which have been constructed for orchard use of which, after considerable correspondence, we have been able to learn exact details. Others, however, have presumably been constructed, and, in fact, Mr. T. B. Wilson, of Ontario County, N. Y., describes, in the Rural New Yorker, July 4, 1896, a machine (fig. 7) which he has had constructed and which he has operated, in the following words:

Last winter I secured a spraying outfit, consisting of a 1-horse Acme engine complete, placed on a frame so that it could be fastened on a platform built for a common lumber wagon, with one small can for the oil and another for the water

supply of the engine. On the back part of the wagon we have a cask that will hold about 150 gallons of water, and from the engine we run a brass rod through the bottom of the tank with two paddles fastened to the rod on the inside of the tank as an agitator—and it is a good one. The steam generated by the engine is conveyed in a pipe to a steam pump (solid brass), and this steam pump does the spraying.

It takes one man or boy to drive the team, two men to operate the nozzles (we use two nozzles of 4 vermorels each), and one to care for the engine. My boy, 13 years old, with the old team, went out among my neighbors. He took charge of the engine; the farmers furnish the other help and all the material, pay $5 per day for the use of the rig, and are much pleased to get it at that price. The common price here for spraying is 4 cents per tree for each spraying, the sprayer to furnish all materials. With this machine we can spray 500 trees, 25 years old, in a day, doing it much better than by hand. The engine carries 100 pounds of steam, and the relief valve is set so that each hose gets 70 pounds pressure to the square inch. I really think that this is the best method yet devised for doing thorough work. We have a fine spray, a good agitator, and a good 1-horse engine for other purposes.

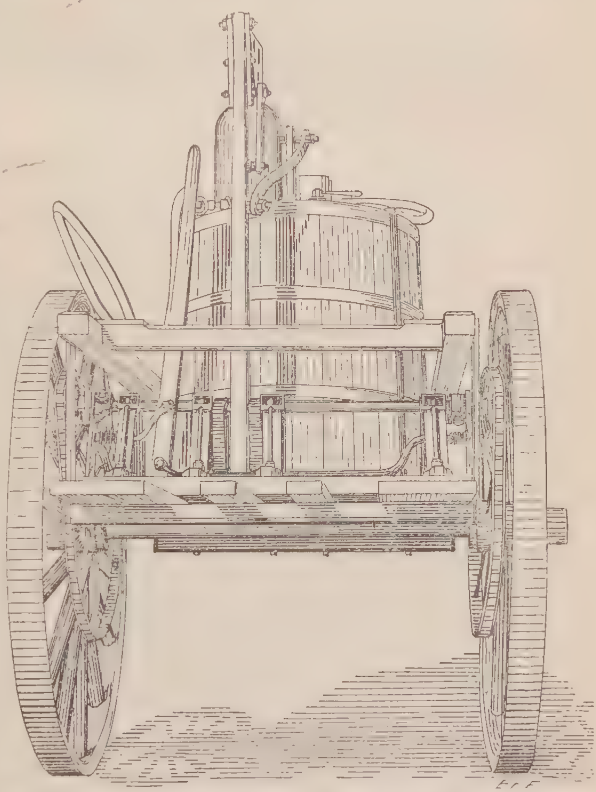

FIG. 8. Geared automatic sprayer used by J. S. Lupton, Winchester, Va.

In this brief account is foreshadowed the probable method of the future use of steam spraying outfits for orchard purposes. It is not likely that the proprietor even of a reasonably large orchard will go to the expense of first cost of constructing a steam spraying apparatus when he already has a hand apparatus which accomplishes the work economically and with a reasonable amount of expedition. In fact, one of the most successful apple growers in Virginia, Dr. John S. Lupton, of Winchester, Va., has told the writer that he would have no use for a steam apparatus. Dr. Lupton, it should be understood, owns a 40-acre orchard of fine Newtown pippins, which he sprays two or three times every year by means

of the machine illustrated by fig. 8. This is a simple apparatus, which sprays by means of an automatic gearing, the motion of the wheels of the tank cart imparting the impetus to the pump by means of a gear chain and sprocket wheel. He runs two lines of hose from his pump and directs them both at the same tree as the horse moves slowly between the rows. One spray is directed at the top of the tree and the other at the bottom of the same tree. In this way one side of an entire row is quickly sprayed, and the horse returning upon the other side this is also sprayed in the same manner. It would seem difficult to spray thoroughly in this manner, but Dr. Lupton has had the best results from his sprayings of any fruit grower of our acquaintance. No further proof of this statement is needed than the fact that he will this year pick 1,200 barrels of unspotted apples from his 40 acres. So perfect is their condition that he has been offered $5 per barrel for the lot. This result has been obtained in what is called an "off year" for apples in the State of Virginia.

The steam apparatus in orchards, however, will be used in the manner Mr. T. B. Wilson has used his. A man with small capital and some mechanical skill has a chance to make money as a public sprayer in a fruit-growing region, and we confidently expect to see the use of steam apparatus developed along these lines to a striking extent.

MACHINES FOR SPRAYING SHADE TREES IN CITIES AND TOWNS.

The other phase of the subject is the use of such apparatus in cities and towns for spraying the shade trees. In a large city, where frequently many thousands of trees are to be sprayed in a short time (the shorter the better), a single steam spraying apparatus will do the work of many hand machines. The writer has repeatedly urged the construction of such an apparatus for shade-tree work in the city of Washington, but has failed to command the needed interest from persons in authority.

It is interesting to contrast with this experience the enlightened energy shown by the Forestry Club of Farmington, Conn. This society has constructed at its own expense an apparatus (fig. 9) which is described by the secretary, Mr. H. H. Mason, as follows:

The outfit consists of a platform 14 feet long, 5 feet wide, made of 2-inch plank, with two 4 by 6 inch timbers, one on each side to strengthen the floor and make a ledge to prevent tools and such things from falling off. This platform is mounted on a set of wheels with rims 6 inches wide and about 24 and 28 inches in diameter, the wheels so arranged that the machine can be turned very short.

The solution tank is an upright cypress tank, built of 2-inch plank, and arranged with iron bands that can be tightened with a wrench as occasion requires to take up shrinkage, the tank being 4 feet in diameter and 4 feet high, with a capacity of 325 gallons.

The pump and boiler was made by the Blake Manufacturing Company of Boston, and consists of an upright tubular boiler 22 inches in diameter and 4 feet high. The pump is of the direct-acting type, with steam cylinder 4 inches and water

cylinder $2\frac{1}{2}$ inches in diameter. The pump is brass lined and fitted throughout with brass. It is capable of delivering two streams of water at a pressure of 150 pounds, with boiler pressure of 90 pounds.

The machine is fitted with pressure gauge and relief valve to prevent bursting the hose in case the hose be suddenly shut off, the pressure gauge's principal value being to show at a glance if the pump is doing its full duty.

Our hose is $2\frac{1}{2}$-inch, heavy mineralized, and will stand 200 pounds pressure; the couplings must be extra strong and strongly put on.

A barrel of water for boiler feed is carried on the platform. Our experience points to the desirability of having the boiler feed pump separate from the steam pump and worked by hand.

A small spraying pump (so called) fastened to the side of the solution tank with hose connections to water barrel and boiler feed cock will prove more convenient and economical of time. This can be worked by the driver when necessary.

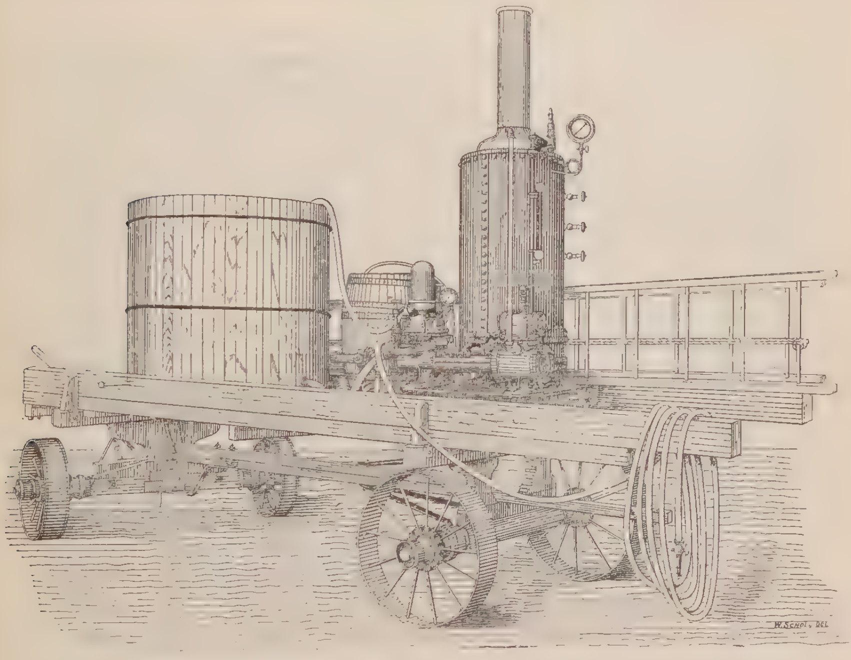

FIG. 9.—Steam apparatus owned by the Farmington Forestry Club, Farmington, Conn.

McGowan nozzles are used. A 35-foot extension ladder, also a 40-foot extension with extra tip 10 feet long, completes the outfit.

These are carried on each side on the timbers before mentioned. The timbers extend 3 feet in rear of the platform, and are used to hang the coils of hose on.

The boiler stands directly over the rear axle, and is fired from the rear end of the wagon. Much difficulty was experienced with the lime solidifying in the pump until we placed a large strainer of very fine brass-wire cloth over the suction in the tank, the sides of the strainer being of board, with the cloth nailed firmly to the edges. It is very efficient and cheap, and is economical, as it saves any manipulation of the lime, such as straining, etc. No trouble by clogging has since been experienced.

We find the stirring of the solution is best done by hand, the driver attending to that with a wooden paddle through a hole 14 inches square in the top of the tank.

A poppet safety valve should be used in place of the lever valve usually sent, on account of the jarring, dislodging the weight on the lever and consequent strain on the boiler.

Two poles, 16 feet and 24 feet, with hose attached, are used on all trees not over 35 feet high, and on the lower branches of large trees, and by saving the climbing facilitate operations very much.

As the direct outcome of the extraordinary abundance of the elm-leaf beetle in the Connecticut River Valley and its northward extension up this valley during the season of 1895, steam-power spraying machines have been constructed by the cities of New Haven, Springfield, and, we are also informed, by Holyoke.

The Springfield apparatus is a compact little machine, to be drawn by one horse, and is illustrated by fig. 11. It was built at a local machine shop, and consists of a boiler, pump, and barrels mounted

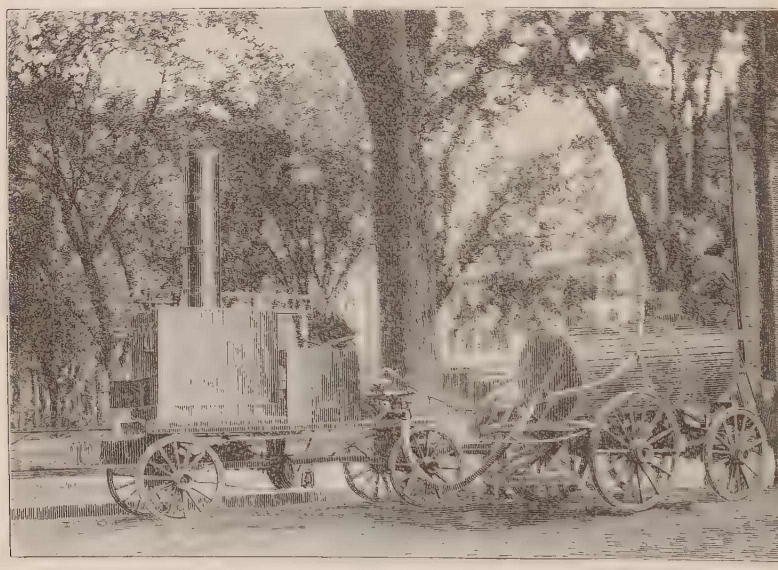

FIG. 10.—Steam spraying apparatus constructed by the city authorities of New Haven, Conn.

upon an open low-hung wagon frame. A small 7-horsepower boiler connected with a Deane pump of 3 horsepower takes up the rear part of the wagon, and in front are the barrels for holding fluids, one for water and the other for solution, the latter holding 120 gallons. The apparatus is fitted with 200 feet of three-fourths-inch hose, with Nixon spraying nozzles. The machine is economical and compact.

With the consideration of the New Haven city apparatus a new principle comes in. A large 4-wheel steam road engine, especially constructed, however, for this purpose, is coupled to an ordinary street-watering tank, in which the spraying mixture is kept in solution. It makes a heavy load for two horses, but six lines of hose are operated at once, and a very strong stream may be thrown from each. The details of this apparatus may be gained from figs. 10 and 12.

This machine has been very successful in treating large elm trees in the city of New Haven. In this city the spraying problem is a serious one. No less than 14,000 elms, many of them 75 to 100 years old, have to be sprayed in a minimum of time.

A steam spraying machine has been used successfully during the past season in the large and beautiful Prospect Park, in Brooklyn, N. Y. This machine was conceived by Mr. J. A. Pettigrew, superintendent of parks, and was an outgrowth of the inadequacy of hand pumps. It is simply a steam pump on wheels, a street-sprinkling tank, and a one-horse supply wagon. Both pump and carriage are simply adapted, being a duplex pump of a capacity of 50 gallons per

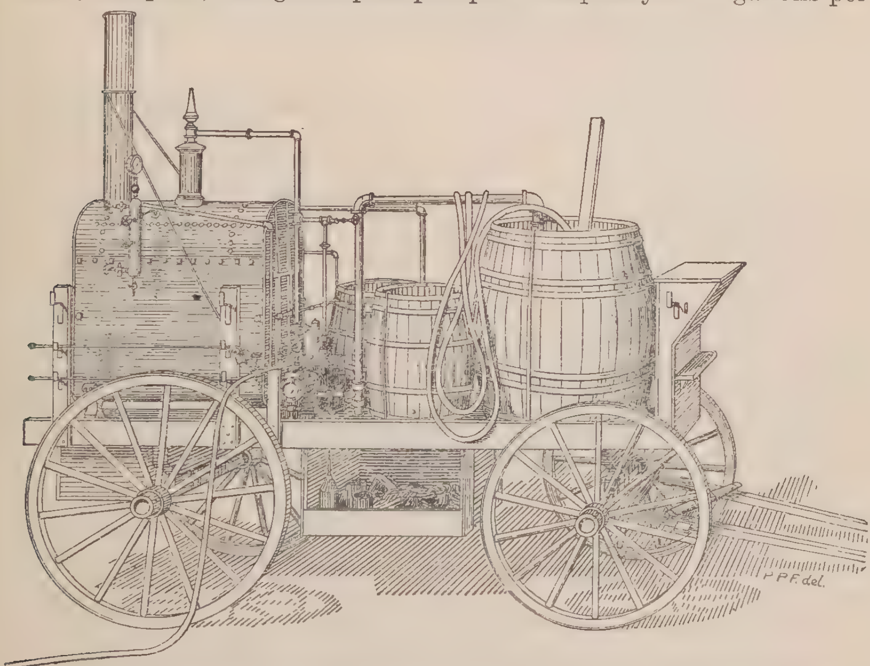

FIG. 11.—Steam spraying machine constructed by the city authorities of Springfield, Mass.

minute mounted on a portable engine truck, the engine being removed. Both are stock goods and obtainable at any pump-manufacturing concern. The park workmen fitted up the attachment for hose connections. The pump truck is attached to the sprinkling wagon, which holds the poison, the capacity of the tank being 600 gallons. The tank itself is an old one, condemned by the street department of the city. The tank and attached truck and pump are easily handled by a pair of horses. The pump carries four lines of three-fourths-inch hose, one connected with the tank, to agitate the mixture, and three for spraying. The suction pipe is 3 inches in diameter. A supply wagon with all that is necessary to carry on the work of spraying, such as tubs and barrels for mixing the poison, is drawn by a single

horse. Comparing the work of this machine with the old hand pumps, Mr. Pettigrew says that while there is probably loss in material it is more than compensated for by the speed in spraying. Speaking of this apparatus, the deputy park commissioner, Mr. Henry L. Palmer, said to a reporter of the New York Tribune:

> This is the only sensible way of dealing with this important matter. We have so many trees that it is necessary to deal with them in a wholesale way. The work can not half be done with hand pumps in the old manner. We have many trees that could not be reached in that way at all. With the steam apparatus, however, we are able to send a good stream to the tops of the tallest trees in the park, and to do the work effectually.

Rather in the same line, but simplifying matters still more, is the

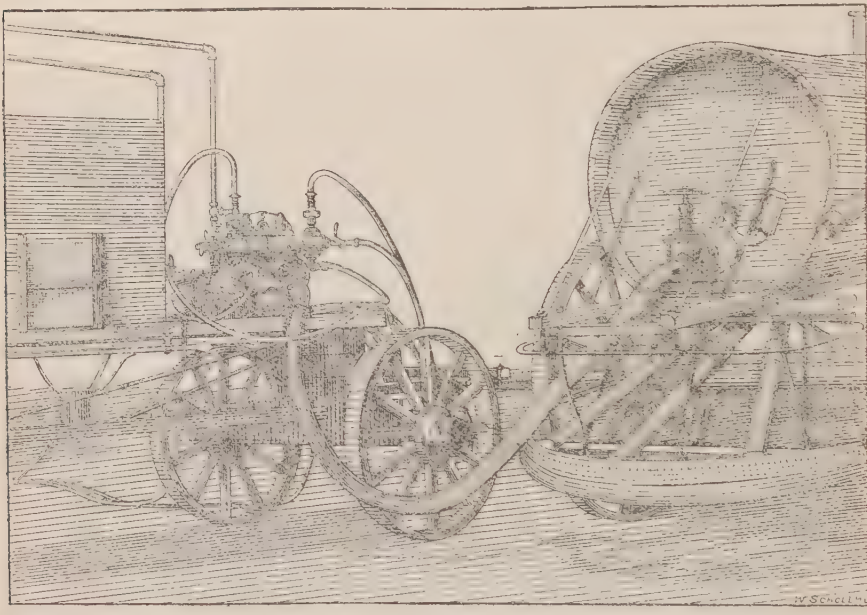

FIG. 12.—Near view of couplings and details of steam spraying apparatus constructed by the city authorities of New Haven, Conn.

plan adopted by Lieut. William Weigel, U. S. A., in charge of the grounds of the United States Military Academy, West Point, N. Y. (fig. 13). There the elm-leaf beetle has annually for many years past partially defoliated the elm trees, and in the writer's article on "The shade-tree insect problem in the eastern United States," quoted above, mention is made of the work of Gen. John A. Wilson, U. S. A., some years ago, at the time when he was Superintendent of the Military Academy. He used the steam fire engine of the post, knocking the insects from the trees by means of a strong stream of water. Lieutenant Weigel has used the poisoned spray, but has utilized a steam fire engine in just the manner suggested by the writer on page 383 of the Yearbook for 1895, although the idea occurred to him independently and without suggestion. He coupled an unused steam fire

engine to an old tank formerly used for disinfecting soldiers' clothes. The tank was mounted on a wagon frame. Two 200-foot lengths of three-fourths-inch hose were attached to the engine, and by this means all trees in a radius of 500 feet were reached. He used the straight nozzle instead of a sprayer, finding that the latter scattered the stream too much and did not allow the mixture to be carried far enough. Each tree was sprayed very carefully by men on ladders, and he found that about 40 gallons of mixture thoroughly sprayed a single tree.

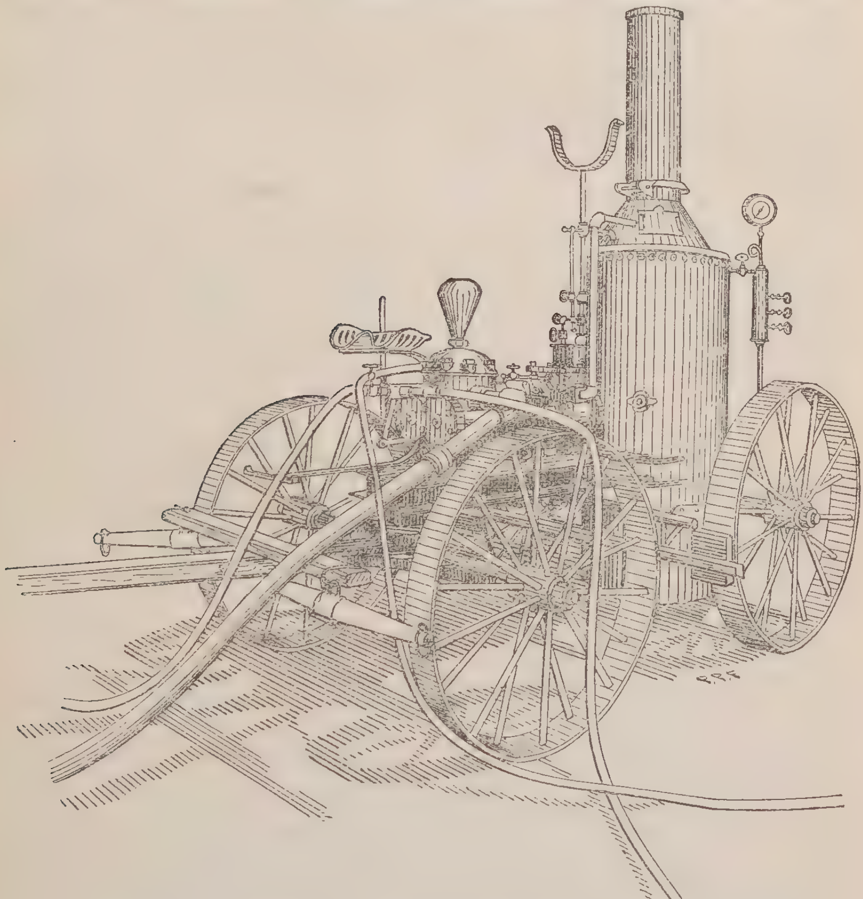

FIG. 13.—Near view of couplings and details of steam spraying apparatus used in Prospect Park, Brooklyn, N. Y.

About 50 trees were sprayed in a day. Four men were utilized in this work, viz, an engineer to run the fire engine, a teamster to drive the supply wagon, and two men to handle spray nozzles. The writer visited West Point late in July, 1896, and the condition of the trees at that time indicated that Lieutenant Weigel had been eminently successful in his treatment.

One objection to most of the city shade-tree machines which we

have so far described has been the fact that the engines are too large and noisy. As has been found to be the case in New Haven, it is necessary to temporarily close the street upon which they are at work in order that passing horses may not be frightened. The noise difficulty has been overcome by a very beautiful and compact little apparatus which has been especially constructed for the department of public parks of the city of New York, under the supervision of Dr. E. B. Southwick, the entomologist of the department. (This apparatus is shown by Pl. I.) Dr. Southwick had previously conducted extensive spraying operations by means of a hand-power pump. The old hand apparatus which he used prior to the present season affords a vivid contrast to the present machine. The motor and pump of the new machine weigh about 300 pounds. The fuel (gasoline) for a

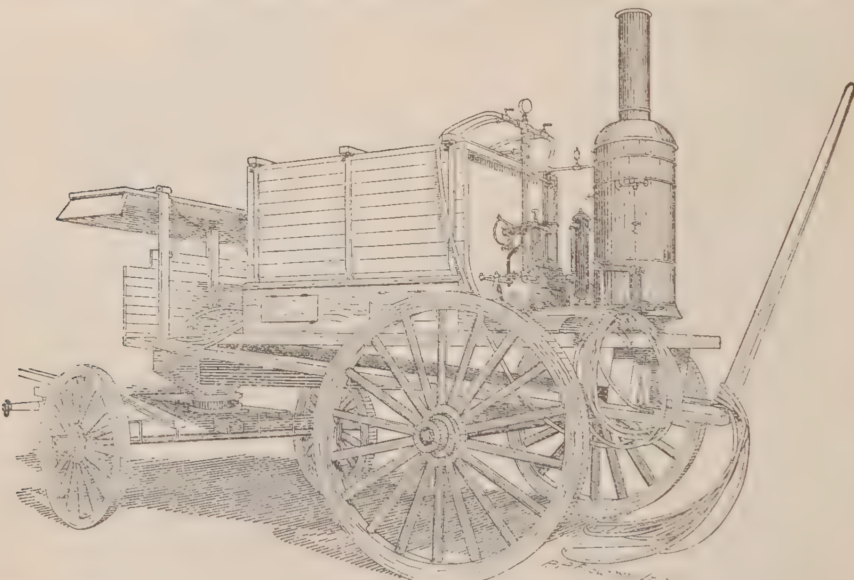

FIG. 14.—Steam spraying apparatus constructed by the Shade and Fruit Tree Protective Association of New York.

day's work is carried in a gallon can. With a small alcohol torch the lamp is lighted, which heats the platinum cap red hot. This cap is hollow, and the gasoline vapor explodes when it comes in contact with it, and in this way drives the piston. The motor is known as the "Daimler," and is one which is extensively used in naphtha launches. Two sections of one-fourth-inch hose with three nozzles on each have been used this summer, but four sections with twelve nozzles may be used if necessary, as the pump supplies 60 pounds pressure. The pump used by Dr. Southwick is a 3-piston Gould pump, the smallest size made of the pattern, and at a pressure of 60 pounds. He informs the writer that if he were to buy another pump he would get a size larger, so as to use more of the power of the motor. As it is,

FIG. 1.—STEAM SPRAYING APPARATUS USED BY THE DEPARTMENT OF PUBLIC PARKS OF NEW YORK CITY.

FIG. 2.—VIEW (FROM OPPOSITE SIDE) OF STEAM SPRAYING APPARATUS USED BY THE DEPARTMENT OF PUBLIC PARKS OF NEW YORK CITY, IN OPERATION.

his motor does not work more than half of its power. The tank shown in the machine illustrated holds 100 gallons. It might easily be constructed to hold more, and would be so constructed except for the fact that in Central Park the machine has to run over the lawns, and hence it is desirable to have it as light as possible. Besides supplying the nozzles, however, Dr. Southwick is in the habit of cooling the motor with the surplus liquid. This motor has been used the entire summer without trouble, and Dr. Southwick states that for his work

FIG 15.—Opposite side of steam spraying apparatus constructed by the Shade and Fruit Tree Protective Association of New York.

in the large parks and running about the city he knows of no machine that compares with it. The motor costs $250, and the pump about $50. The total cost of running the machine a day amounts to but a few cents. It is comparatively safe, and a tyro can run it. It is almost noiseless, and is used with the utmost safety on the Central Park drives, where the slight noise made by the motor is not noticed by the horses. Readers of this article acquainted with the Mall in

Central Park will appreciate the havoc which might be created by a noisy steam engine.

We have elsewhere referred to the growing idea of community spraying, or to the building of a steam spraying apparatus by an individual who operates it at a fixed rate per day in orchard work. A similar development of shade and ornamental tree spraying is also gradually being brought about. In a paper read before the Association of Economic Entomologists, at Springfield, Mass., in the summer of 1895 (see Bulletin 2, new series, Division of Entomology, pp. 40–47), the writer referred to the work of W. S. Bullard, of Bridgeport, Conn., in this direction, and anticipated an increase in spraying as a business. The same point was brought out in the Yearbook for 1895 (pp. 383–384). The defect in this plan, as there pointed out, arises from the fact that not all property owners or residents can afford to employ a tree sprayer, while others are unwilling, since they deem it the business of the authorities or do not appreciate the value of tree shade. This defect, however, is anticipated only from the standpoint of complete protection, and there are undoubtedly many wealthy residents in our larger cities who will gladly pay an individual or a company to spray the trees upon their own grounds, or, in case of lack of enterprise on the part of city authorities, the street shade trees in front of their houses. Taking advantage of this condition of affairs, there was established in New York City during the winter of 1895–96, a company entitled "The Shade and Fruit Tree Protective Association," which has had several excellent steam spraying machines constructed, and has done during the summer of 1896 a very considerable amount of tree spraying. The first work carried on by this company was done under contract with the Yale University authorities by spraying the very large and beautiful elms upon the Yale College campus. The writer witnessed the initial experiments in early July, studied the machine, and secured photographs from which the illustrations of figs. 14 and 15 were reproduced. The machine used by this company is a most excellent one. The tank, which has a capacity of 300 gallons, is mounted upon a strong platform 10 by 4 feet in dimensions, the wagon trucks being especially constructed for it and fitted with broad-tired wheels. The engine has a capacity of 4-horse-power, and there are four streams with a discharge pressure of 60 pounds each. The hose is three-fourths-inch in 200-foot lengths, and the nozzle rods are iron and each 10 feet long. The McGowan nozzle is used. A supply cart, run by a single horse, is in more or less constant use, and a complete outfit of telescope ladders accompanies the machine. The tallest trees on the Yale campus were expeditiously sprayed. The engine used was built by the Shipman Company, and is of the type described elsewhere.

It seemed to the writer that there was with this machine, as with all others which he has had opportunity of seeing, an unnecessary waste

STEAM SPRAYING APPARATUS USED IN PROSPECT PARK, BROOKLYN, N. Y.

of material and a disagreeable amount of dripping from trees after spraying. This is in every case due to the fact that the insecticide is not thrown as a finely divided spray, but is thrown in a coarse spray or a more or less solid stream, which divides upon striking the branches and foliage. Inasmuch as in all this large-tree work the operatives have to climb the trees, the use of a nozzle which will throw as finely divided a spray as possible seems to the writer to be desirable. A more thorough wetting of the leaves, particularly of the leaves of the elm tree, will be accomplished in this way. As is well known, if a large drop of water is thrown upon the under surface of an elm leaf the close pubescence of the surface will cause it to run off. A spray from a cyclone nozzle, however, is so fine that a complete wetting of the surface is brought about by its use, and there is almost no resultant dripping and consequent loss of material. The use of a small hose also seems desirable. This will be perfectly practicable if a fine-spray nozzle is used. The gain in facility of operation with a half-inch hose or even one of three-eighths inch will be very great. To carry a three-fourths-inch hose up into a tall tree requires an exertion of much muscular strength. The substitution of bamboo supporting poles for the iron rods used with the last-named apparatus will also be desirable on the same grounds.

A point which has been brought out in this large-scale spraying is the fear of the poison on the part of those who may be employed. The writer has made many inquiries regarding possible injurious results, but has as yet heard of only one case which seemed to indicate that the contact of the spray with the skin may be injurious. In this case a more or less severe eruption of the hands and neck followed almost immediately upon a rather thorough wetting with an ordinary solution of arsenate of lead (3 pounds to 100 gallons). Another man was just as thoroughly wet at the same time without any injurious results, and it seemed to the writer that the eruption in the first case, which was of a severely itching character and which recurred with every hot spell of weather for more than a year, must have been due to some other cause. It will be noticed in the picture of the Prospect Park apparatus (Pl. II) that the men are clothed in uniform caps and suits and wear rubber gloves. Mr. Pettigrew, who has charge of the operations, thinks the gloves entirely unnecessary, but the men insist upon using them.

CONCLUSIONS.

To sum up, and in conclusion: Aside from the first cost of the apparatus, spraying by steam power is economical on a large scale. Some extensive orchardists may find it worth while to construct such an apparatus, since the difficulties experienced by Messrs. Wolfskill and Goodwin are overcome in the more recently constructed machines.

In fruit-growing communities in which many hand sprayers are not

already in use, the construction of a steam apparatus will probably become a paying investment for an enterprising individual. The plan of charging a per diem rate for the use of the machine, the owners of the orchards to furnish spray materials and labor, aside from the running of the engine, seems to us the best plan to adopt, the plan of guarantying protection against insect pests having obvious disadvantages.

In any city or town having abundant shade trees it will unquestionably, in the writer's estimation, pay the city authorities to place at the disposal of the street commissioner or superintendent of parks sufficient funds for the construction of such an apparatus, for instance, as that used by the department of public parks in New York City. An expenditure in this direction will be more economical, it would seem, in the long run, than the adoption of what may be termed the "makeshifts" used in New Haven, the Brooklyn parks, and at West Point. The extreme economy in the operation of such an apparatus has already been shown, and the point of its noiseless operation is a very important one.

It will be gathered from what has been said in this article that there is a growing appreciation of the value of shade trees and a growing interest in their preservation. From both æsthetic and utilitarian points of view they are valuable city property, and the increasing public interest will undoubtedly result in the ultimate adoption of the recommendations which the writer made in the Yearbook for 1895.

INFLUENCE OF ENVIRONMENT IN THE ORIGINATION OF PLANT VARIETIES.

By Herbert J. Webber,

Assistant, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

GENERAL REMARKS.

In traveling from country to country or from section to section even a casual observer will notice the different characteristic features presented by plants. The desert traveler notes the prevalence of succulent, fleshy plants, and dwarfed, spiny shrubs; the alpine traveler observes the dwarfed habit, the showy flowers, and the prevalence of woolly, or hairy plants. Desert, prairie, mountain, and alpine regions, forests, lakes, and marshes, all have their general characteristics, and when these salient features of plants in similar regions are found to be the same the world over, one can not but infer that it is probable that similar physical conditions produce similar results. Indeed, it is a well-recognized fact that different soils, climates, altitudes, and locations have an effect on the plant and lead to certain characteristic variations. Darwin repeatedly says that "variations of all kinds and degrees are directly or indirectly caused by the conditions of life to which each being, and more especially its ancestors, have been exposed."

Plants growing in the same region, but of widely different affinities, are frequently found to present similar characteristics of general growth, and this similarity may be carried down to the most minute details of structure. A large portion of such structures are of direct value to the plant in resisting the deteriorating effects of bad climate and in better adapting it to the conditions of life which it must endure.

While plants in the ordinary sense of the term are motionless, we know that they are rapidly spread from region to region, frequently to long distances, by the seeds being carried through the agency of wind, water, or animals. When a seed is lodged and germinates in a region widely separated from that in which the parent developed, whether it will manage to thrive will depend upon the physical conditions of the place in which it is lodged, and the inherent variability, so to speak, of the plant. If the seed of a plant which normally grows on a moist, rich soil should be lodged in a sandy desert, it may

grow and reach maturity if it is capable of varying its normal structure sufficiently to meet the necessities of desert life. Certain protective adaptations are necessary in desert plants, and introduced plants must produce these features to a greater or less extent if they are to fit themselves for withstanding the severe heat and drought of desert climates. It has been found by repeated observations, and has been proved beyond doubt by many experiments, that plants possess in a marked degree the faculty of varying to adapt themselves to such adverse conditions.

Cultivated plants are subjected largely to the same condition, and will vary in a similar manner. The cultivator, however, attempts to ameliorate the harsh features of the natural environment, for if the soil is sterile it is manured, and if the rainfall is scanty the deficiency is supplied by irrigation, or the soil is cultivated to conserve the available supply of moisture. Many climatic and soil conditions, however, can not be overcome by the cultivator, and therefore the varieties he selects must either be adapted to his region or else be capable of sufficiently varying to adapt themselves to the new conditions, otherwise the planting will not be successful.

The general variability of plants to meet the requirements of different regions is well recognized, but the fact that the individuals of the same species or variety, growing side by side in the same locality, differ from each other is not so generally understood, although this is as true as that different varieties and different species are unlike in their general characters. If a row of nursery trees of the same variety of apple or orange is carefully examined, one tree will be found to branch low, requiring pruning to shape it correctly; another will run up tall and unbranched, and will require topping; one will branch here and another there, and one will have small leaves and another large ones. While in general the individuals are alike, yet a comparison of any two trees will show many points of difference. Every individual plant has a distinct facial expression, so to speak, by which it may be recognized, just as certain characteristic differences in the individuals of a herd enable the stock raiser to distinguish one from another. The differences are not always describable, but nevertheless they exist. It is this faculty of the individual to vary that enables plants to fit into the numerous chinks in which they are compelled to grow.

It is not the intention to discuss here the causes and reasons for all variations which occur in plants. There are many variations apparently without any direct inciting cause, or, as Professor Bailey expresses it, "some variation is simply fortuitous—an inevitable result of the inherent plasticity of organisms." Plants are not, as is sometimes supposed, of fixed habit, that is, unvarying, from generation to generation, but are essentially plastic and variable. Fixed types have not now the significance they had a few years ago. Fortuitous

variation would appear to be more common in plants which have been long under cultivation than in those still in a state of nature. These variations may be largely the indirect results of changed conditions, but in cultivated plants conditions have been so frequently changed that it is impossible to refer the variations to any immediate cause. Many are probably the outcome of the cumulative results of numerous changes of external conditions, but this we can only infer to be the case.

Sex is also an important factor in producing variation, and must be considered in order to reach an understanding of the great variability which exists among plants. The crossing and commingling of the characters of unlike individuals result in endless combinations. The importance of intelligent crossing in improving the varieties of cultivated plants can not be overestimated, but the variations produced in this way do not concern us here. We are at present interested simply in those modifications which are produced by change of environment, and a consideration of how desirable changes of this nature can be induced by the intelligent cultivator.

VARIATIONS RESULTING FROM CHANGED CONDITIONS.

The principal factors of environment which are potent in inducing marked variations in plants are food supply, water, light, temperature, altitude, growth in maritime or saline regions, and change of climate. Several of these factors frequently act together in bringing about certain variations.

FOOD SUPPLY.

This is probably the most important factor in causing variability, both in wild and cultivated plants. Darwin says, "Of all the causes which induce variability, excess of food, whether or not changed in nature, is probably the most powerful." Thomas Andrew Knight, however, was probably the first to clearly enunciate this law, which is now generally understood. The great sensitiveness of plants to food supply has led to many of our common agricultural practices. It is for this reason that we isolate our plants, and cultivate, plow, and manure the soil. When seed raisers desire to keep a true stock of any one kind of seed, they grow it on poor land without manure.

The first and most common variation resulting from excessive food supply is a general increase in size, which at first is relatively the same in all parts of the plant, the leaves, stems, roots, and fruits increasing in practically the same ratio. Besides this increase in size, which is of great value from a commercial standpoint, a greater tendency to vary is also induced. If the excessive nutrition is continued during several generations, different parts of the plant will sooner or later be found to vary in other directions. The seeds, fruits, or flowers for which the plant is cultivated will, in certain

individuals, increase in size slightly more than the relative proportion as compared with the other members of the plant, and it is by carefully watching for these slight variations and propagating from them and again selecting from their progeny that many of the valuable varieties of our cultivated plants have been developed. Experience teaches that when once variation of this nature has set in, other variations in shape, texture, color, flavor, etc., which it is desirable should appear in cultivated varieties, may reasonably be expected.

Lack of food results in a reduced size of all organs, and may greatly modify the plant. Plants growing for any length of time in soils deficient in food are greatly reduced in general vitality and the weakened constitution is apparently transmitted to the offspring. Weak and poorly fed individuals produce small seed, with little stored nourishment, and these in turn necessarily produce seedlings which are small, stunted, and poorly fitted for the battle of life. Roujon, by selecting and planting only the smallest seeds from the least-developed specimens of sunflower, corn, and other plants, obtained in two years very small plants. The corn was reduced in size to about 8 inches high. As the height diminished the number of seeds decreased, and the final result was absolute sterility.

Mr. Henslow found that seedlings of large seeds, owing to their greater vigor, crowd out the seedlings of small seeds. A continual selection of the small seeds for several generations, he says, will cause the plants to die out altogether by failing to produce seed, or else a tiny race of beings will for a time be maintained. These vegetable runts, the result of insufficient nutrition and insufficient light, are of common occurrence in nature. Mr. B. T. Galloway, by growing selected lots of large and small radish seed, found that "the large seeds germinated more quickly and with more certainty, and produced marketable plants sooner and more uniformly than the small seeds." The latter, however, "gave proportionally larger plants." In this case, which at first thought seems confusing, we see, as Mr. Galloway suggests, the effect of long-continued, natural, methodical selection. The radish is cultivated for the root, and selection has thus been continually directed to increase the size of this part without attention to the seed. If more nutrition is utilized in root development with plants of equal vigor, less would probably remain for seed development, resulting naturally in small seed. Thus, long-continued selection, aiming only to increase the size of the root, which is done with some detriment to the seed, might be expected to ultimately lead to an inherited tendency of the small seeds to develop large plants, and vice versa.

Cuttings, offsets, and any part of the plant used in propagation are subject to the same modifications as plants produced from the seed, and are individually affected by external conditions. If they are weakened and stunted from lack of nutrition, their chance of success

is greatly reduced, as they are then more liable to be seriously affected by adverse conditions and to become a prey to various diseases. If too greatly reduced in size and vigor, no amount of care and attention can lead to success. Abundant inherent vitality is the basis of success in the cutting or offset just as it is in the seed. In the Yearbook for 1895 (p. 254) Mr. Galloway emphasizes the difference which external conditions produce in violet cuttings and the necessity of selecting vigorous cuttings. If grown too near salt water or on too dry soil, the pineapple slip may be so stunted that the best care and attention will fail to revive it, although it may continue to grow slowly and ultimately form a small fruit. Strawberry growers find it desirable to exercise considerable care in selecting vigorous plants in order to keep up the vitality of their stock. If the new plants are taken from beds which have been weakened by attacks of leaf blight or leaf spot disease (*Sphærella fragariæ*), they almost invariably suffer severely from attacks of the same disease and are further reduced in strength.

The advantage arising from cultivators in different sections exchanging seeds, bulbs, and cuttings, which has for years been a common practice in many countries, is evidently due to the slight benefits derived by the plants from change of soil. Darwin informs us that "the belief that plants are thus benefited * * * has been firmly maintained from the time of Columella, who wrote shortly after the Christian era, to the present day."

Bailey considers that "much of the rapid improvement in fruits and vegetables in recent years is due to the practice of buying plants and seeds so largely of dealers, by means of which the stock is changed." However, if the food elements were present in every soil in the same quantities, it is not probable that any benefit would result from this practice. There is some evidence to show that where artificial manuring is practiced there is apparently no necessity for a change of seed, as no noticeable benefit is derived therefrom. This practice in itself, however, is a yearly change in the nutrition, as the amount, kind, and quantity of the manure used commonly differ each year. Plants in nature secure, to some extent, the benefit derived from a change of seed by the various devices for accomplishing their dissemination. Indeed, it may be that these numerous devices have been developed partially through the benefits derived by a change of soil in keeping up the vitality of the species, instead of being, as is commonly supposed, an attempt on the part of the plant to simply disseminate the seeds that they may have room to develop.

It is probable that the physical character of the soil affects plants and induces certain variations entirely apart from the effects due to the food or water content. Carrière found that by cultivating the wild radish, or jointed charlock (*Raphanus raphanistrum*), which has a slightly fleshy root, in rich soil he could produce the common

cultivated radish. He further found that the form of the root produced depends upon the character of the soil, the round form resulting from growing in heavy, close soil, and the long-rooted form from growing in loose, light soil. Pliny is said to have recorded the same effect as known and utilized in Greece in his time. These forms, as a result of continuous selection, are now hereditary by seed.

The difference in fertility of soils leads to much variation in wild plants, and is unquestionably a common cause of differentiation into varieties and species in nature. The juniper, or red cedar (*Juniperus virginiana*), which is a common forest tree throughout most portions of the United States, has so adapted itself to varying conditions that, as Professor Sargent says, it seems equally "at home on the dry, gravelly hills of New Brunswick and New England; * * * in the fertile valleys of Pennsylvania; on the limestone hills of eastern Kentucky and Tennessee, where it forms, with stunted and shrubby growth, great forests or 'cedar brakes;' in the swamps of the Florida peninsula, and on the rich bottom lands of the Red River." If the soil is rich and moist, and the trees are not crowded by others competing for the light, the juniper forms a beautiful pyramidal top, of symmetrical outline (fig. 16). This is the common form in the fertile valleys of New York, Pennsylvania, Maryland, and Virginia. On dry, rocky hills and on barren, sandy soils, where there is a deficiency of water and nutrition, the juniper may grow in equal abundance and seems to be as thoroughly in harmony with the conditions, but in such places it forms a low, spreading, shrubby tree, of entirely different habit (fig. 17).

WATER.

The effect of the quantity of water in the soil or of growing in a water medium is very marked on most plants, but has not been of great importance in inducing variations in cultivated plants. Serious lack of water (a condition which is found in deserts and sandy regions) has given rise to various devices by plants to prevent loss of water by evaporation from the leaves, water storage reservoirs in the tissue, specialized glands to absorb dew, etc. Desert trees and shrubs are commonly stunted, gnarly-stemmed plants, with large root systems. The fact that these characters almost invariably disappear (frequently in the first generation) when the plants are grown where there is an abundance of water and food, shows that they were assumed because of a lack of these materials.

The bald cypress (*Taxodium distichum*) furnishes an interesting illustration of the effect of excess of water. The cypress, as is well known, grows usually at the present time in swamps and very wet places. Geological records, however, show that centuries ago, previous to the Glacial epoch, the cypress tree grew in the present Arctic region, associated with oaks, maples, etc. As it was forced

southward by the gradual change in climate, competition with other trees evidently resulted in its present habit of growing only in swamps. Plants growing on dry land secure the necessary oxygen needed in root growth from the air, which is always present in the soil. Plants growing in the water or on very wet soil, however, frequently find it difficult to secure sufficient oxygen, and this has led to the development of devices to facilitate the aeration of the tissue. Cypress trees growing in water form numerous protuberances on the roots known as "cypress knees," which extend above the water into the air (fig. 18). By growing numerous seedlings of the cypress under varying conditions, Dr. Wilson has shown that these roots are invariably formed by plants growing in water, and are never formed when the plants are grown on fairly dry soil which contains sufficient air. He concludes, therefore, that these peculiar organs enable the roots of the tree to secure the necessary oxygen, and are developed as a direct result of the habit assumed by the cypress of growing in swamps. It is an interesting fact that this habit of forming knees, which was acquired centuries ago, has not become hereditary, being totally lost the first generation if the tree is grown on dry soil. In swamps and on lake margins, which places are now its natural home, the bald cypress forms a ragged, spreading growth, with large limbs and sparse foliage, and is very different from the common type of closely related pine trees. This also is the result of a lack of oxygen and food, as before stated (fig. 18). When the tree is grown on dry soil, as it frequently is in parks, where it secures abundant air and nutrition, it reverts to the normal type, forming a tall, symmetrical, columnar top (fig. 19). In this case no knees are developed. The difference in the form of the top developed in the swamp and that developed on uplands or in parks is evidently due to the difference in food supply, as in the case of the juniper.

Many plants grown in water or on wet soils have developed devices similar to cypress knees in order to secure aeration. The black mangrove (*Avicennia nitida*) and swamp mangrove (*Laguncularia racemosa*), which grow abundantly in tidal marshes in south Florida, develop numerous specialized roots, which, instead of growing downward in the normal way, grow upward to such a height that they are exposed to the air a large part of the time, being covered with water only at high tide (fig. 20). The height of these roots above the soil varies from 2 to 18 inches, according to the location, and they are frequently very numerous where the trees are crowded together in salt marshes. In a marsh on Biscayne Key, Florida, where the swamp mangrove forms almost the only vegetation, the writer counted eighty-three of these roots in a square foot. Their average height in this case was about 5 inches. In some places these trees may be observed growing on fairly high and dry soil, in which case the aerating roots do not develop.

The effect of abundant water and nutrition on the development of spines in certain plants is interesting and suggestive. Spininess, as already mentioned, is a common characteristic of plants which naturally grow in dry, barren regions. Lotheler found that by growing barberry (*Barberis vulgaris*) in a moist atmosphere it bore no spinescent leaves, while in an arid atmosphere it bore only spines. Similar results have been obtained by a number of experimenters. Many plants which are normally thorny, such as roses, plums, oranges, etc., are known to frequently lose their spines as a result of cultivation and selection.

LIGHT.

The effect of the light supply in determining the form of plants is well recognized. If a grass seed germinates under a tub, the little plant does not spread out at random in its growth. If the edge of the tub is raised to admit a ray of light, instead of growing upright, as it naturally would, the shoot bends toward the ray of light and grows by the shortest path to the opening. After passing into the full light it develops its normal form. The form and direction of growth of every branch is determined largely by the accessibility of light. The form and structure of every leaf also are just as largely dependent upon the light supply. Innumerable differences in the shapes of individuals of the same species are caused by the struggle to obtain light. Branches develop in positions where their leaves can be unfolded to the light with the least obstruction. The natural round and full symmetry of the tree grown in an open place is due to the unobstructed action of the light on branch development. Trees have developed their habit of lofty growth by a continuous struggle to secure light. The same inciting cause has led to the development of the habit of twining in certain plants. Other plants have so modified their structure that they are able to secure sufficient light in the shade of the forest. Sleep movements of plants are other well-known reactions of light. In cultivation, the necessity of light is well recognized, and our plans for planting fields and gardens are made with reference to the plants used in order to secure the necessary light and nutrition for the best development of each individual.

TEMPERATURE.

Heat increases transpiration, or the loss of water, by evaporation from the leaves, and the modifications induced by this factor of environment are largely to avoid excessive evaporation, as in the case of desert plants, mentioned elsewhere. Tropical plants frequently develop their leaves naturally in a nearly vertical position, so that one edge or the point of the leaf is turned toward the sun. Thus, at noon, when the heat is greatest, the leaf receives the glancing rays of the sun and distributes them over its entire surface instead of their

striking only a small part, as would be the case were the surface of the leaf in a horizontal position.

Unless too intense, heat hastens growth, while cold either retards or entirely checks it. When grown in tropical regions, many of the common vegetables of temperate regions either fail to develop or else become unfruitful because of the excessive heat. "To make European vegetables under the hot climate of India yield seed," says Ingledew, "it is necessary to check their growth, and when one-third grown they are taken up and their stems and taproot are cut or mutilated."

Fig. 16.—Juniper, or red cedar, pyramidal form (Potomac Valley, Washington, D. C.).

Very severe cold also causes stunted individuals. This effect is seen in alpine plants, one of the principal characters of which is a dwarfing in general size, or "nanism." The great aridity and intense light, which are also characteristic features of alpine regions, have led to modifications in the general structure of alpine plants similar to the modifications found in plants growing in desert regions.

For several years Dr. Gaston Bonnier has grown many plants both on plains and in alpine regions, and has proved that in all cases plants growing on the plains if transported to an alpine region acquire a number of definite characteristic modifications which adapt them to alpine life. The roots become much larger relatively in comparison with the top; the stem becomes shorter and more hairy, with fewer and shorter internodes; the leaves become smaller, more compact, and more hairy, with thicker epidermis and of darker color, and the flowers become relatively larger and of a brighter color. The common dandelion (*Taraxacum officinale*), which grows spontaneously in all latitudes up to the last limits endured by flowering plants, illustrates in an interesting manner the

Fig. 17.—Juniper, or red cedar, barren soil form (east Florida).

variations produced by growth in an alpine climate. An examination of fig. 21 will show the reduction in size of a plant, leaves more nearly perfect, comparatively larger size of root, etc.

FIG. 18.—Bald cypress, swamp form, with aerating roots, or knees.

EFFECT OF THE SEA.

Plants grown near the sea, where they get the effect of the salt air and salt water in the soil, vary uniformly in certain ways. The effect of the salt in the soil is to increase the density of the soil water and make it more difficult for the plant to secure the necessary moisture. The plant reacts by developing devices to store up water and to retard evaporation. Lesage found that plants growing by the sea develop much thicker leaves—a device for water storage. The leaves of sea kale (*Cakile maritima*) grown by the sea were four or five times as thick as those of plants grown inland. The beet (*Beta vulgaris*) had the leaves similarly thickened in the proportion of eight to three. The common garden pea (*Pisum sativum*) watered with salt water produced much thicker leaves than usual. The sea grape (*Coccoloba uvifera*), which is a common plant in south Florida and tropical countries, will serve as an illustration to show the extent of variation produced by the sea and also by cultivation. This plant grows very abundantly on the sand dunes immediately bordering the coast, where it is exposed to the salt spray which is carried by the wind from the breakers. The sands of the dunes are very dry and

FIG. 19.—Bald cypress, pyramidal cultivated form.

FIG. 20.—Aerating roots of swamp mangrove (*Laguncularia racemosa*)—one-half natural size.

sterile and somewhat shifting in nature. Under these conditions the sea grape forms a stunted shrub from 2 to 3 feet high, and composed largely of unbranched stems (fig. 22). The branching top of the tree in this case, however, is largely developed below the sand, the groups of upright stems being connected by underground stems. Under these conditions the sea grape is remarkably fertile, almost every stem forming a cluster of fruit. Its beautiful foliage has led to its being cultivated to some extent as a lawn plant, and when grown in fairly rich, moist soil it forms a beautiful, upright tree, with

FIG. 21.—Common dandelion (*Taraxacum officinale*): *a*, common form, grown in plains region at low altitude; *b*, alpine form. Both *a* and *b* are reduced in the same scale. (Adopted from Bonnier.)

dense foliage (fig. 23), entirely different from the maritime form. Under cultivation the sea grape is as yet generally unfruitful, but it will probably become more prolific if its cultivation is continued until it becomes more thoroughly domesticated.

CHANGE OF CLIMATE.

Change of climate, which may involve a change of some or all the principal factors of environment discussed above, has led to many interesting variations in our cultivated plants. A remarkable variation in American corn when grown in Europe is given by Metzger. Seeds of a tall variety, obtained from the warmer parts of America,

"during the first year produced plants 12 feet high, which perfected a few seeds. The lower seeds in the ear kept true to the parent form, but the upper seeds became slightly changed. In the second generation the plants were from 7 to 10 feet in height and ripened their seed better. The depression on the outside of the seed had almost disappeared, however, and its original white color had become duskier. Some of the seeds had even become yellow, and in their now rounded form they approached common European maize. In the third generation nearly all resemblance to the original and very distinct American parent form was lost. In the sixth generation the maize perfectly resembled a European variety."

FIG. 22.—Sea grape (*Coccoloba uvifera*), maritime sand-dune form (Palmbeach, Fla.).

FIG. 23.—Sea grape (*Coccoloba uvifera*), cultivated.

Sterility is frequently the result of changed conditions. Alpine plants, though naturally very fruitful, usually become sterile when cultivated in gardens, as do also many bog plants. Excessive manuring frequently results in sterility by inducing excessive vegetative growth, but this is a wholly different matter, for the plants referred to do not flower. Sterility, which so commonly results from introducing plants into cultivation, is from some effect of domestication other than running to leaves from excessive food, as they may flower abundantly, but not set fruit. Continued cultivation, however, in most

plants results finally in an increased fruitfulness over what was produced in a state of nature, and this, as is plainly seen, is the keynote to cultivation. Bailey gives an interesting case of a Paraguay Physalis, or husk tomato, which he grew in New York from seeds sent from Paraguay. "I grew it both in the house and out of doors, and for two generations was unable to make it set fruit, even though the flowers were hand-pollinated; yet the plants were healthy and grew vigorously. The third generation grown out of doors set fruit freely." In some cases, however, even long-continued cultivation has not resulted in the plant regaining its equilibrium sufficiently to become perfectly fertile. The lilac and geranium may be cited as plants that have been long under cultivation, and while retaining all the essential organs of the flowers in apparently perfect condition, they seldom form seeds.

Again, sterility in some cases is a result of long-continued and excessive cultivation. Almost all fruits which have been long under cultivation and have been largely propagated by cuttings, suckers, budding, grafting, etc., produce seedless varieties, as in the case of the orange, pineapple, banana, apple, etc. Long-continued propagation and selection of plants for their fruit seem to result in a tendency to fruit production entirely independent of seed production, so that we now have many varieties of cultivated plants which develop apparently normal fruits without pollination, and consequently do not form seeds.

HOW TO INDUCE DESIRED VARIATIONS.

The above cases will show to some extent the forms of variations which are liable to occur from changed conditions as they occur in nature or under cultivation. To successfully utilize this faculty which plants have of varying their structure to suit conditions or as a result of conditions, we must endeavor to learn how to induce the variations desired and then improve and fix them by intelligent selection. It is the universal belief among horticulturists that the most important step toward improving wild plants is to first "break the type," that is, to induce the species to vary in any direction whatever. When once variation is started, a slight change in the desired direction may confidently be expected sooner or later if the conditions favoring such variation are given. While theoretically there would seem to be no limit to the variation which might be expected in any direction or of any part desired, yet there is a practical limit. It is not desirable to attempt to develop a plant with fleshy, edible roots, like the radish or turnip, from a plant having fine, fibrous roots. For development, plants should be selected which in nature have shown a marked tendency to develop in the desired direction. "Nature gives the hint. Let men follow it out rather than attempt to create new types of characters." Should it be desired to develop a

fleshy-rooted plant, there should be selected for the experiment a wild plant having somewhat fleshy roots. If an improved fruit is desired, the selection should be made from the numerous wild fruits which are already edible.

As before pointed out, plants in nature vary greatly, but under uniform conditions are very stable. To induce variation, a change of conditions is of prime importance. Excess of food, as shown, is probably the most potent factor in inducing variability. This is secured by isolating the plants, cultivating, manuring, etc. Pruning is simply carrying the idea a step farther, as removing one branch leaves a larger supply of nourishment for those remaining, or removing a portion of the fruit or flowers leaves a greater food supply for the development of the others and results in a larger growth. The first variation induced by excessive food supply is usually increased size and vigor—an initial variation of value, as it is at first of prime importance to secure larger fruits, seeds, or roots, after which attention can be given to flavor, size, shape, texture, etc. Growth in rich, moist soil tends to increase the size and produce a tender, succulent growth; to delay maturity and thus endanger the plant in Northern climates by its greater sensitiveness to cold; to lessen the saccharine and pungent qualities, etc. If, on the other hand, more dwarfed plants are desired, they may be induced by scanty food and water supply, or by transferring the plants to alpine or desert places. Frequent transplanting and sowing seeds late in the season may also be of benefit in checking growth and inducing a dwarfed habit. It is well known that growing plants in small pots and crowding the roots, only occasionally repotting to give them more room as the plant develops, retards the growth and usually results in dwarfed plants. An increase in fruitfulness is often caused by removal to a higher latitude or altitude. The same result may in some cases be secured by decreasing the food supply and thus checking the tendency to excessive vegetative growth. More vivid coloration of fruits, flowers, or leaves may be induced by transferring the plants northward or to higher altitudes; modifications in flavor may be produced by change of climate and of food and soil conditions, and greater succulency can be obtained by transferring to saline regions or growing on soil watered regularly with salt water. If seeds of hardy annual plants are sown late in the fall, so that they can not mature their seeds, a tendency may be produced to store up the reserve nourishment in the root, which by selection may establish a biennial habit. Vilmorin converted the carrot, which is normally an annual plant, into a hereditary biennial by sowing the seed late in the season till the character of flowering the second season became fixed.

In attempting to develop seedless fruits, so commonly the result of long-continued cultivation, the endeavor must be, as stated by Dr. Lewis Sturtevant, who has studied and written extensively on this

subject, to give the most intensive culture possible. Excessive manuring and varying the ingredients; cultivating thoroughly; increasing the size of the fruit by pruning; continued propagation by cuttings, budding, grafting, etc.; changing the climatic conditions; crossing, and hybridizing, indeed almost all the practices of intensive modern horticulture, increase the tendency to seedlessness.

The production of the initial variation is quite uncertain. All that man can do is to cultivate the plants continuously under the conditions most favorable to the production of the variation desired, and patiently and carefully watch for signs of variation in the desired direction. In some cases the variation may very quickly follow the change of conditions, while in others the type is very persistent and difficult to break. In all cases, however, patience and persistence will be sure to ultimately meet with success, for no instance is known of a plant being long under cultivation and not furnishing several varieties. In fact, plants which have been long and extensively cultivated, especially under conditions of sharp competition in trade, have almost invariably yielded numerous varieties, as in the case of the apple, wheat, etc.

FORMATION OF VARIETIES BY SELECTION.

When variation in the direction desired has been secured, it then remains for the cultivator to improve it into the desired form by careful and methodical selection. As Darwin expresses it, in the formation of varieties of cultivated plants "the key is man's power of accumulative selection. Nature gives variations; man adds them up in certain directions useful to him." Seeds from the individual showing the desired variation are sown under the same conditions which resulted in producing the initial variation. The resulting seedlings are in turn very carefully inspected and seeds taken from the one which shows the greatest increased variation in the desired direction. It is by this methodical selection generation after generation that the final triumph is attained.

It is necessary to have well in mind the ideal variety which it is desired to produce, so that selections may be made with a well-defined point in view. All features can not be improved at once. It is well to attempt only one improvement at a time. If attempts are made to simultaneously reduce the number of seeds and to change the shape of the fruit by selection, failure in both directions or but slight success might be the result. The important feature should be given strict attention, and only sufficient care devoted to the secondary features to keep them up to the standard. In developing a certain feature by selection it may falsely appear that it is this organ alone that varies. Careful attention to other features will, however, show that they also vary, and probably fully as much, but as no attempt is made to fix or

increase these variations they are mostly lost. If such secondary variations are not detrimental, no attention need be given to them.

Many of the valuable varieties of cultivated plants which have appeared in recent years have been the results of bud sports, fortuitous variations, crossing, hybridizing, etc., but it is probable that the great majority of our cultivated plants were developed simply by selection. This is indicated by the fact that the majority of them were brought into cultivation by our early ancestors while still in a savage or semicivilized state, when all methods of agriculture were the simplest possible. Many of these were so modified by culture before records were kept that the original types from which they were developed are not known and can not be distinguished with certainty. It is not at all probable, considering the crude methods employed at that period, that any means of development could have operated other than simply the selection of seeds for propagation from the best variations which appeared under this crude culture.

The time it requires to produce valuable varieties by selection depends much upon the inheritability of the variation which is being developed and fixed. The degree of inheritability of variations produced by environment are very different. The definite variations which are produced by plants as reactions under changed environment, such as dwarfed habit, caused by transferring the plant to alpine regions, or succulence, caused by transferring to maritime regions, are usually lost the first generation if the normal conditions are restored. It is certain, however, that as long as the changed environment is continued the modifications are regularly produced, and usually in a gradually increased degree (progressively modified), frequently forming well-marked varieties. Continued growth under the same conditions evidently in most cases gradually leads to establishing the inheritability of the variation. In many instances, however, variations produced by environment, which variations have been formed regularly every generation for centuries, have not yet become sufficiently fixed in habit to be inheritable. Such are cypress knees, aerating roots of black mangrove, etc., which are lost the first generation if the inciting cause is removed. How great a variation must be or how many generations it must be formed to acquire stability can in no case be stated. The selection by man from each generation of those plants which show the most marked variation in the desired direction, and propagating only from seed selected from these, tends to greatly promote fixing the inheritability of the character.

The selection of wild radish, or jointed charlock, seeds, carried on for some time by Carrière, resulted in the production of several varieties of radishes similar to those commonly cultivated. In the same way seeds of wild parsnip, selected by Professor Buckman from the best-rooted plants during several generations, produced a variety in which the large root and glabrous leaves were hereditary. Both

Vilmorin and Carrière obtained similar results with the wild carrot by selection. Monnier's change of winter wheat to summer wheat and summer wheat to winter wheat furnishes an interesting illustration of the quick changes which are sometimes wrought by change of conditions and careful selection. Monnier "sowed winter wheat in spring, and out of 100 plants, 4 alone produced ripe seeds. These were sown and resown, and in three years plants were reared which ripened all their seed. Conversely, nearly all the plants raised from summer wheat sown in autumn perished from frost, but a few seeds were saved and produced seed, and in three years this summer variety was converted into a winter variety."

When once the ideal variety has been attained by selection and is found to be propagated by the seed, it would seem desirable that variation should cease, at least in this particular strain of plants; but plants in all conditions and in all places are markedly plastic and variable. If it is desired to keep the variety true to the type, the most rigid care is necessary in destroying all variations that may appear. "Roguing," or destroying the nontypical plants, is regularly practiced by good seedsmen. Most varieties which have been extensively cultivated for any length of time have varied greatly, aided often by the unconscious selection of the cultivator, until they are entirely different from those first introduced under the names which they bear. In regard to the pea, Darwin states that "the greater number of varieties have a singularly short life. Thus Loudon remarks that 'sorts which were highly approved in 1821 are now (1833) nowhere to be found,' and on comparing the lists of 1833 with those of 1855, I find that nearly all the varieties have changed." Bailey estimates that "every decade sees a complete change in every variety of any annual species which is propagated exclusively from seeds, and every century must see a like change in the tree fruits." The change is not necessarily detrimental to the variety; indeed, the opposite is usually true. The almost universal unconscious selection usually results in gradual improvement, but along different lines. The changes wrought in the variety are commonly so gradual that we do not realize that they are taking place unless the most careful attention is given to keeping the variety pure. Seedsmen and gardeners become expert in recognizing departures from the type, and this acuteness has a twofold object. On the one hand it is desired to keep the variety true, and on the other to detect desirable variations. In the extensive fields of the large seed firms all detrimental or unpromising variations are destroyed to keep the variety true, and all promising variations are retained for selection and improvement. The demand for novelties sharpens the seedsman's wits. In a few years, as a result of the discovery of a promising variation, or "rogue," the Perfected Delmonico melon or the Improved Golden wax bean is introduced. These varieties are the result of the seedsman's most careful

attention in breeding the variations for several generations and in carefully selecting and destroying the "rogues," until the new type has become practically fixed and hereditary.

We have thus far considered only the development of variations caused by environment through seed selection, as this seems to be the only sure way of fixing and rendering such variations hereditary and transmissible through the seed. In plants that are propagated regularly by cuttings, suckers, etc., similar improvements may be wrought by careful selection. Bud variations, or sports, which may be the indirect result of changed conditions, are usually marked variations, which can not be improved by seed selection, as the variation is not usually reproduced by the seed. Improvements in such cases must be by bud selection.

The improvement of plants by careful selection and fixation of variations, crossing, hybridizing, etc., while in one sense a well-worn field of practical investigation, is in another sense new and promising. The demand for novelties is constantly increasing, and at no previous time have results in this direction met with so ready appreciation. The diversification and extension of fruit and vegetable industries into new regions creates a demand for varieties adapted to various conditions. As the conditions are numberless, the field for improvement seems almost inexhaustible. No branch of horticulture or agriculture promises more important and remunerative results than may be attained by intelligent plant breeding. Rather more than ordinary intelligence is necessary to satisfactorily conduct such work, however, and the desirability of a thorough preparatory training, such as may be obtained in our State agricultural colleges, can not be overestimated.

POTASH AND ITS FUNCTION IN AGRICULTURE.

By H. W. Wiley,

Chief of the Division of Chemistry, U. S. Department of Agriculture.

ORIGIN OF POTASH.

The potash naturally present in a soil, in common with its other mineral constituents, is the residue of the decomposition of the minerals which composed the original rocks. The common salts of potash, viz, phosphate, chloride, sulphate, etc., are soluble in water, and where disintegrated rocks are subjected to leaching these salts are in a great measure removed. In the original rocks the potash is chiefly held in the structure of silicates, more or less complex, and wholly insoluble in water. In the débris of these rocks, as found in the soil, it is evident that the potash must still be held in the insoluble state, but, nevertheless, so thoroughly decomposed as to be yielded gradually to the demands of the growing plant.

LOSS OF POTASH DURING WEATHERING.

During the progress of decomposition a portion of the potash passes into the soluble state and is removed by the leaching produced by heavy rains. This fact is conclusively shown by the chemical analysis of fresh and decomposed rocks of the same structure and occurring in the same locality. For instance, in the analysis of a fresh and decomposed rock (diabase) near Medford, Mass., it was found by Mr. G. P. Merrill that the undecomposed sample contained 2.16 per cent of potash, and the disintegrated portion 1.75 per cent. From these data it is seen that by leaching during and after weathering the diabase lost 19 per cent of its potash.

In comparing the soil, partially disintegrated rock and undecomposed granite, from which the fresh and decomposed rocks were derived, near Rock Creek, in the District of Columbia, almost the same relative loss was found, the percentages of potash in the rock, decomposed rock, and soil being, respectively, as follows: 2.71, 2.11, and 2.10, showing a loss in passing from the fresh rock to the complete soil of 23.5 per cent.

From these data it is safe to conclude that in virgin soils, formed in situ and free from erosion, from 70 to 80 per cent of the potash present in the original rocks will still be found. It would evidently be useless to seek for any constant relation between the potash in sedimentary soils and that in the rocks from which they were originally

formed. In these soils is found a mixture of sediments of very different origins and of different degrees of fineness, the finest particles being evidently carried to the greatest distance, or being last deposited. In the finer particles of such a soil there is naturally a great disturbance of relations, and the potash itself is distributed among such particles in proportion to its solubility and the specific gravity of the intact rock fragments containing it.

PERCENTAGE OF POTASH IN FELDSPARS.

The mineral constituents of rocks which afford the largest quantities of potash to the soil are the potash feldspars. The rocks containing this mineral are widely distributed. Feldspar itself is essentially a silicate of alumina associated with the silicates of potassium, sodium, or calcium. Magnesia and iron are either absent or occur in very small quantities. The predominating alkali is either potash or soda, although where potash predominates there is nearly always some soda, and where soda predominates a small quantity of potassium is found. The amount of potash in feldspars varies widely; it is in general from 5 to 15 per cent. In a variety of feldspar found at French Creek mines, Warwick, Pa., 15.99 per cent of potash has been found; at Magnet Cove, Hot Springs, Ark., 15.60 per cent; at Leverett, Mass., 12.20 per cent. Feldspars of this kind have as much potash as the fertilizing material known as kainite, described further on. It is evident that if such feldspars were readily decomposable, yielding the potash in a form soluble in water or easily dissolved by the vital activity of the rootlets, they would be quite as valuable for fertilizing purposes as the kainite of commerce. In point of fact, however, these feldspars, as a rule, disintegrate slowly, and it is probable that there would be no immediate effect produced by applying them, even in a finely ground state, to the soil. Sooner or later, however, the process of disintegration would be sufficiently advanced to render the potash assimilable, little by little, by the growing crops.

Feldspars may be altered or disintegrated by infiltrating waters carrying more or less carbon dioxide in solution, and also by the action of waters rendered acid by the decomposition of sulphides, or a mineral containing the protoxide of iron is often the first occasion of the change. When the infiltrated waters contain carbon dioxide, the feldspar first loses its lime, by a combination of the lime with this acid, and next a portion of its potash is carried off as carbonates. The residue, being chiefly silicate of alumina, becomes a kind of kaoline. The carbonate of soda or potash or the silicate of those bases may be used in the formation of other minerals, while the alkali goes to supply the saline ingredients of fresh and marine waters. The decomposition of feldspathic rocks near the surface of the earth evidently proceeds in such a way as to distribute extremely fine

particles of the partially undecomposed minerals throughout the soil. These mineral particles contain the residual potash of the original mineral in a form which may be slowly used for agricultural purposes. In localities subjected to heavy rains the water-soluble form of the potash resulting from weathering is not found except in very limited quantities, but, as indicated in the analyses cited, the quantity of the potash lost by this solvent action does not in many instances exceed 20 or 25 per cent of the total quantity present in the original rock.

DISTRIBUTION OF THE POTASH IN THE SOIL.

When a soil is separated by water into groups of particles of approximately the same size, the potash is unequally distributed among them. In one instance it has been shown that a soil containing 0.63 per cent of potash afforded sediments in which the potash was distributed as follows: In the clay (21.64 per cent of the whole) 1.47 per cent; in silt less than a quarter of a millimeter in diameter (23.56 per cent of the whole) 0.53 per cent; in silt half a millimeter in diameter (13.67 per cent of the whole) 0.12 per cent. The total potash in all the sediments amounted to 0.49 per cent of the weight of the soil, showing a loss of 0.15 per cent, which is ascribed to the solvent action of the water used in effecting the separation.

RELATIVE SOLUBILITY OF PARTICLES OF DIFFERENT DEGREES OF FINENESS.

The solubility of soil particles of different degrees of fineness in an acid, such as hot hydrochloric, is, as a rule, inversely proportional to their size. The clay, therefore, possesses the highest degree of solubility, and the coarser particles in the order of their size are less soluble. Thus, while a soil may lose a portion of its potash in passing from a state of larger to one of smaller aggregates, the residual potash becomes more readily soluble, and therefore more easily assimilated by the plant. In the coarser particles of the soil are retained those mineral constituents of plant food which, in the course of years, become gradually available. Nature thus conserves the potash, as well as other mineral foods, in a most careful manner, giving up only limited portions each year.

RELATION OF POTASH TO OTHER MINERAL INGREDIENTS IN SILTS OF DIFFERENT MAGNITUDE.

As a result of the studies of the composition of the silts, the following conclusions may be drawn:

1. The iron and alumina exist in almost identical relative proportions in each sediment, making it probable that they are in some way definitely correlated.

2. Potash and magnesia also exist in almost the same quantities,

and their ratio to each other in all the sediments being almost constant seems to indicate that they occur combined, perhaps in some zeolitic silicate which may be a source of supply to plants.

3. Manganese exists only in the clay, a mere trace being found in the next sediment.

4. The lime appears to have disappeared in the clay, having probably been largely dissolved in the form of carbonate by the large quantity of water used in elutriation. Its increase in the coarser portions may be owing to its existence in a crystallized form not so readily soluble.

5. In a summary of the ingredients, it is seen that there is a loss in potash, magnesia, and lime in the sediments as compared with the original soil, and this loss is doubtless partly due to the solution of these bodies in the water of elutriation.

A noteworthy fact is the rapid decrease of acid-soluble matter in the coarser sediments.

DISTRIBUTION OF POTASH IN THE SOIL AND SUBSOIL.

A study of the distribution of the potash in the soil and subsoil may be undertaken from two points of view. In the first place, the total quantity present in each may be determined. This result does not take into consideration the availability of the potash, nor its relative solubility in different menstrua, but represents only the total quantity present in every form.

In the second place, an attempt may be made to determine only that portion of the potash which is soluble in a given menstruum under set conditions, representing, presumably, the quantity of potash immediately or successively available for the nourishment of plants.

In ten samples of typical soils and subsoils, representing different parts of the country, the total average quantity of potash found and also the quantity soluble in hot hydrochloric acid, on digestion for ten hours, are as given in the following table:

Soil.	Total potash.	Potash soluble in HCl.
	Per cent.	*Per cent.*
Virgin surface	1.880	0.413
Virgin subsoil	2.050	.386
Cultivated surface	1.858	.421
Cultivated subsoil	1.979	.391

These data show that there is slightly less potash in the surface than in the subsoils, and this indicates that the leaching of the surface soil and the abstraction therefrom of the potash by the growing plants tend to diminish the total quantity of potash therein as compared with the lower layers of soil where these extractive forces are less vigorous. On the other hand, the data show that the potash

in the surface soil is more soluble in hydrochloric acid than that contained in the subsoil. This condition is brought about by the greater exposure of the surface soil to weathering influences and by the action of cultivation in reducing partially decayed mineral fragments to a finer state of subdivision and to the biochemical activity of soil ferments and plant life. The evident deduction is that while the surface contains slightly less potash than the subsoil, the potash in the former is more easily assimilable than that in the latter. In this connection it should be noted that, with one or two exceptions, the surface soils used in the above analyses had never been treated with any potash fertilizers. It is evident, however, that the relative quantities of potash in soils and subsoils may vary from geological and meteorological causes and with the character of crop and cultivation.

RELATIVE ACTIVITY OF DIFFERENT SOLVENTS FOR POTASH.

From the data given, it is seen that hydrochloric acid extracts, in round numbers, 20 per cent of the total potash in the soil. The exact numbers for the different soils are as follows:

	Per cent.
In virgin surface soil	21.92
In virgin subsoil	18.83
In cultivated surface soil	22.66
In cultivated subsoil	19.76
Mean for forty samples	20.79

The quantity of potash which weaker solvents abstract from a sample of soil depends largely, not only on the nature of the solvent, but also on its relative quantity when compared with the soil samples, the length of time the sample is subjected to digestion with the solvent, and the temperature and the degree of mechanical agitation to which the mixture is subjected. In comparative determinations, made in the division, it has been shown that organic acids and their salts extract much smaller quantities of potash from the soil than hot, strong hydrochloric acid. The weakest of these solvents gives results more concordant with the quantity of potash taken from the soil by growing crops than can be obtained by the use of more effective solvents.

PERCENTAGE OF POTASH REMOVED FROM SOILS BY WEAK ORGANIC ACIDS.

It is generally assumed that one of the chief factors active in securing the solution of potash in the soil is the acid secretion of the rootlets of plants. The acidity of this secretion is due to a weak organic acid—citric, malic, or oxalic—and for this reason it is justly supposed that the solvent action of a weak acid on a soil more nearly represents the natural action of a plant than any other method of extraction.

Unfortunately, the degree and nature of the acid secretion of rootlets can not always be determined, and therefore any attempt to imitate the natural process by laboratory methods must be more or less empirical.

In addition to this, no use can be made in the laboratory of the vital and vegetal forces which undoubtedly exercise a great influence on the solubility of the constituents of the soil. Nevertheless, it is interesting to study the action of dilute organic acids on soils, and especially to compare it, under fixed conditions, with the data got from the crop itself.

It has been found in experiments here, on eight typical soils from different parts of the country, that the following mean quantity of potash is removed by digesting 200 grams of fine soil for five hours with 1 liter of a 1 per cent citric acid solution at a temperature of 100° F.:

	Per cent.
Total mean quantity of potash in soils	1.5910
Total mean quantity of potash removed by hydrochloric acid	.2580
Total mean quantity of potash removed by citric acid	.0074

In comparing these data for the eight soils examined, the following facts appear: Hydrochloric acid extracts 16.2 per cent of the total potash; citric acid extracts 0.45 per cent of the total potash. The citric acid is, therefore, more than thirty-six times as weak a solvent for potash as hydrochloric.

In making this comparison, however, it must be remembered that the extraction with hydrochloric is made with strong acid at a temperature of boiling water, while the extraction with the citric acid is made with a very weak solution and at a temperature but very little above that of the workroom. For equal degrees of concentration, equal temperatures, and equal times of digestion the difference in solvent power would not be so marked.

AMOUNT OF POTASH IN ONE ACRE.

An acre contains 43,560 square feet of surface, and in a depth of 1 foot, 43,560 cubic feet of soil.

The weight of a cubic foot of dry soil varies greatly, according to its nature, a sandy soil being heaviest, and a peaty soil lightest. For common arable soils the weight is about 80 pounds per cubic foot. The total weight of an acre of dry soil, taken to the depth of 1 foot, is therefore about 3,484,800 pounds. Since a very fertile soil contains about 2 per cent of potash, it is seen that the total weight of this substance in an acre of soil, measured as above noted, is 69,696 pounds. A crop removing 50 pounds of potash a year could be grown consecutively for nearly one thousand four hundred years on such a soil before its content of potash would be entirely exhausted.

Many fields are found, however, in the older continents which have

certainly been under cultivation for more than four thousand years, and which still contain notable portions of potash. It is evident, therefore, that the stores of potash are either conserved by fertilization or are gradually restored from the deeper and apparently inexhaustible supplies afforded by the progressive decay of subterranean rocks. Referred to the weight of the soil on the above data, the percentage of potash removed by a single crop consuming 50 pounds of potash per acre is almost infinitesimal, being represented by the fraction 0.0000143. Based on the total quantity of potash, the amount removed by one crop is 0.000717 per cent. These quantities are so small that it is quite beyond the limit of accuracy in analytical work to determine them definitely. It is undoubtedly true, however, that the assimilability of potash depends, to a large extent, upon the quantity thereof soluble in either hydrochloric acid or in some one of the organic acids or its salts which may be used for extraction. Fortunately, the rootlets of plants come into intimate contact with only a very small portion of the soil in which they grow, and it is the semisoluble potash in these soil particles that serves for plant food. When, however, a small quantity of potash, soluble in water, is added to the soil, nearly the whole of it, under favorable climatic conditions, may be absorbed by a single crop. It is evident, therefore, that treatment with hydrochloric acid, and even with dilute organic acids or their salts, will not give us the data of actually available potash, but they may afford a basis on which the proportion of available potash may be calculated. The soil holds a certain quantity of fertilizing materials with such tenacity as to render it practically impossible for plants to entirely absorb the supply and leave the fields utterly impoverished. Thus nature to a certain extent defends the future against the rapacity of the present, for it is certain that should science discover a method whereby all the fertilizing ingredients of the soil could be made available in fifty years, aggressive agriculture would not hesitate to take advantage of the opportunity.

QUANTITY OF POTASH WITHDRAWN FROM THE SOIL BY THE MORE IMPORTANT CROPS.

It is evident that the quantity of potash withdrawn from the soil by a given crop varies from year to year with the abundance of the harvest and with meteorological conditions. In determining the mean annual contribution of potash, it is sufficient to ascertain the mean yield of the crop for a series of years and base the estimates thereon. The potash which enters into a crop is not all removed by the harvest. A part remains in the roots, when these are not harvested, and in the straw or other débris left in the field. The most complete removal of the potash takes place with root crops, such as the sugar beet, where both tops and roots are gathered. The minimum harvested

quantity of potash entering into crops and subject to harvest is found in fruits, in maize gathered from the stalk, in cotton, and in wheat and other cereals harvested by headers. In making estimates of the quantities of potash removed by the principal crops, the above statements are taken into consideration. In the principal cereal crops, of the magnitude noted, which represent about the average production of the United States for 1895, the quantities of ash in grains and straw, the percentage of potash therein, and the weight of potash per acre are given in the following table:

Crop.	Acres.	Bushels.	Weight of ash in grain.	Per cent of potash in ash.	Weight of potash.
			Pounds.		*Pounds.*
Maize	82,075,830	2,151,138,580	1,860,800,000	27.93	519,721,440
Wheat	34,000,000	450,000,000	556,200,000	31.16	173,311,920
Oats	27,800,000	824,450,000	839,400,000	16.38	137,493,720
Barley	3,300,000	87,075,000	120,640,000	25.00	30,160,000

Crop.	Weight of ash in straw.	Per cent of potash in ash.	Weight of potash in straw.	Total weight of potash in grain and stalks.	Potash removed per acre.
	Pounds.		*Pounds.*	*Pounds.*	*Pounds.*
Maize	10,306,240,000	22.96	2,370,435,200	2,890,156,640	32.8
Wheat	2,436,798,600	13.65	332,623,000	505,934,920	14.9
Oats	2,068,000,000	22.12	457,441,600	594,935,320	21.5
Barley	334,080,000	22.85	76,838,400	106,998,400	32.4

The mean quantity of potash removed per acre by the cereal crops mentioned above is 27.9 pounds. The hay crop of the United States at the present time is about 50,000,000 tons per year, grown on an area of about 45,000,000 acres. The mean content of ash in dry hay is about 7 per cent, and the total ash of the hay crop is, therefore, 3,500,000 tons, or 7,000,000,000 pounds. The mean percentage of potash in the ash of hay is about 23, and the total weight of potash removed from the soil by the hay crop is, therefore, 1,610,000,000 pounds, and the weight per acre about 36 pounds.

The quantities of potash removed per acre by other crops are as follows:

Crop.	Quantity per acre.	Total potash.
		Pounds.
Potatoes	100 bushels	50
Sugar beets	10 tons	95
Sugar cane	20 tons	44
Cotton	Crop yielding 180 pounds of lint	23
Tobacco	1,000 pounds leaves	70
Flax	15 bushels, 1,800 pounds straw	27

For an average harvest the quantities of potash removed from the soil by some of the principal crops in Germany are given in the following table:

Crop.	Potash.		Corresponding to kainite.	
	Kilos per hectare.	Pounds per acre.	Kilos per hectare.	Pounds per acre.
Forage beets	256.5	229	1,035	924
Sugar beets	147.6	131	575	513
Potatoes	97.8	87	380	349
Rye	52.3	46	205	183
Wheat	38.2	34	150	133
Oats	58.5	52	230	205
Barley	36.2	32	140	125
Peas	49.9	44	195	165
Beans	93.9	84	365	325
Clover hay	83.7	74	325	290
Lucerne hay	116.8	104	455	406
Tobacco	81.8	73	320	285

QUANTITIES OF POTASH IN DRY VEGETABLE SUBSTANCES.

Different plants in a dry state contain very different quantities of potash, and these variations are equally well marked in the different parts of each plant.

Dry tobacco leaves contain a larger percentage of potash than any other common agricultural plant, viz, about forty parts per thousand. Tobacco is of all crops the one which has the greatest need of potash food. The proportions of potash in some other common crops, reckoned as parts per thousand of the dry substance, are as follows: Forage beets, 35; potatoes, 20; sugar beets, 18; red clover, 19; mixed hay, 16; beans, 13; peas, 10; rye (kernels), 6; wheat (kernels), 5; oats (kernels), 5; barley (kernels), 5; maize (kernels), 5.

In the dry straw, the parts of potash in one thousand are as follows: Beans, 19; oats, 16; barley, 11; peas, 10; rye, 9; wheat, 6.

RELATIVE QUANTITIES OF POTASH IN KERNELS AND STRAW.

In cereal crops about four times as much potash is removed in the straw as in the grain, while in peas, beans, and other crops of that kind the proportion is about two to one in favor of the straw. This is an important fact to be considered in preserving the straw of these crops for forage and manurial purposes.

From the foregoing statements it is easy to determine the drain on the potash stores of the soil which is made by the leading field crops of this country. These data are based on the average production per acre of the crops noted. In many localities the quantity of the crop produced may be very much greater or less than the average, and in these cases the loss of potash must be correspondingly increased or diminished.

AVAILABLE POTASH.

From the data given it is seen that the total quantity of potash removed from the soil by a single crop is an almost infinitesimal percentage of the weight of the soil. Even on the assumption that the total acidity of the excretions of the rootlets of plants is correctly represented by a citric acid solution of 1 per cent strength, it is clearly evident that the digestion of a small quantity of soil with an excess of the reagent is a process totally different from that of nature where the quantity of solvent is many thousands of times less than the quantity of soil. Nevertheless, a comparison of the quantities of potash removed from the soil by such a solvent with the actual quantities removed by the crop can afford valuable data for approximately estimating, by purely chemical means, the degree of availability of the potash present. Experience has shown that when a soil yields as much as 0.01 per cent of potash to a 1 per cent citric acid solution, the addition of potassic fertilizers does not produce an economic increase in the crop, while, on the other hand, when the quantity of potash extracted by the citric acid falls to 0.007 per cent, potash fertilizers give a most decided increase in yield. In this connection it should be noted that the quantity of carbonate of lime in the soil has an important restraining bearing on the action of citric acid in liberating potash. It is evident that a large amount of experimental work must yet be done before this question receives a satisfactory answer.

ORIGIN OF POTASH DEPOSITS.

It has been stated that in the decay of rocks containing potash a notable proportion of the potash, varying in amount from 20 to 40 per cent, is lost by solution and carried into the streams. The potash thus passing into solution finds its way either into the lakes or the ocean, where it is subjected to the general laws of segregation which govern the formation of mineral strata deposited from water.

As is well known, in the deposition of mineral matters there is exerted a natural selection in such a way as to bring together those of like character. This selection is exerted chiefly through the different degrees of solubility of the mineral matters and the relative proportions thereof existing in solution. It is evident that even a highly soluble substance when dissolved to saturation in a liquid will be deposited when a portion of that liquid is evaporated or if it be reduced in temperature. As a result of this law of deposition, we find the layers of various stratified rocks and of rock salt, sulphate of lime, sulphate of magnesia, sulphate of soda, and the sulphate and chloride of potassium.

All the potash salts which have been carried into the sea and lakes either still remain in solution in these waters, have been removed by the animal and vegetable life therein, or are deposited in layers in company with their other mineral constituents.

The recovery of the waste potash is chiefly secured by the isolation of sea waters containing large quantities of this salt, and their subsequent evaporation. Such isolation of sea waters takes place by means of geologic changes in the level of the land and sea. In the raising of an area above the water level there is almost certain to be an inclosure of the sea water, of greater or less extent, in the form of a lake. This inclosure may be complete or only partial, the inclosed water area being still in communication with the main body of the sea by means of small estuaries. If this body of water be exposed to rapid evaporation, as was doubtless the case in past geologic ages, there will be a continual influx of additional sea water through these estuaries to take the place of that evaporated. The waters may thus become more and more charged with saline constituents. Finally a point is reached in the evaporation when the less soluble of the saline constituents begin to be deposited. In this way the various formations of mineral matter, produced by the drying up of inclosed waters, take place.

The most extensive potash deposits known are those in the neighborhood of Stassfurt, in Germany. According to the best authorities, the Stassfurt deposits of potash had their origin in past geologic epochs by the isolation of a part of the sea, the waters of which were heavily charged with potash salts. This isolation was at first incomplete, and as the evaporation of the inclosed waters took place they were supplied by small estuaries leading to the ocean, and by a continuation of this process the percentage of saline matters in the waters rapidly increased. In those ages the climate of Europe was still tropical, and the rate of evaporation was therefore much more rapid than at the present time. The less soluble materials, such, for instance, as gypsum, naturally were the first deposited, and as common salt was the most abundant mineral ingredient, these deposits of gypsum were covered with thick layers of rock salt as the next deposit. This layer ultimately reached a thickness of 3,000 feet, and it is stated by geologists that it required at least 13,000 years to form it. The deposit of rock salt is not continuous, but is broken occasionally with lamellated deposits of sulphate of lime and, toward the top of the formation, by layers of the mineral called polyhalite, which consists of the sulphates of lime, potash, and magnesia. Above these deposits are found other layers containing the mineral kieserite (sulphate of magnesia). Above the kieserite line the chief deposits of potash salts consist mainly of the mineral carnallite, composed of muriate of potash and chloride of magnesia. The carnallite deposit is from 50 to 130 feet in thickness, and yields the most important quantity of the crude potash from which the manufactured salts of commerce are made. Above the layer of carnallite is found a covering of clay which is almost impervious to water, and it is this water-tight covering which has preserved the soluble mineral deposited under it from subsequent solution

in percolating rain water. Had it not been for this protection these deposits of potash, now so valuable to agriculture, would long ago have been washed away and lost.

Again, above the clay is another stratum of sulphate of lime, showing that after the deposit of the clay the original process of the deposition of mineral matter was continued, since above the sulphate of lime is found again a layer of rock salt; but this rock salt is of a purer quality than that of the first layer mentioned. The deposits are completed by another layer of sulphate of lime and of impervious clay capped by sand and limestone, which crop out at the surface of the soil.

The perpendicular distance from the surface to the lowest of the Stassfurt salt deposits is about 5,000 feet, while the horizontal extent of the bed is from the Harz Mountains to the Elbe River in one direction and from the city of Magdeburg to the town of Bernburg in the other.

The saline formation near Stassfurt is situated at the bottom of a vast triassic deposit surrounding Magdeburg. The quantity of sea water which was evaporated to produce the deposits of more than 500 meters in thickness must have been enormous, and the rate of evaporation great. It appears that a temperature of boiling water would have been quite necessary, acting for a long time, to produce this result.

It is therefore admitted that all the theories so far advanced to explain the magnitude of these deposits are attended with certain difficulties. What, for instance, could have caused so high a temperature? The most reasonable cause must be sought for in the violent chemical action produced by the double decompositions of such vast quantities of salts of different kinds. There may also have been at the bottom of this basis some subterranean heat, such as is found in certain localities where boric acid is deposited.

Whatever be the explanation of the source of the heat, it will be admitted that at the end of the Permian period there was thrown up to the northeast of the present saline deposits a ridge extending from Heligoland to Westphalia. This dam established throughout the whole of north Germany saline lagoons in which evaporation was at once established, and these lagoons were constantly fed from the sea.

There was then deposited by evaporation, first of all, a layer of gypsum, and afterwards rock salt, covering, with few exceptions, the whole of the area of north Germany.

But around Stassfurt there occurred at this time geologic displacements, the saline basin was permanently closed, and then by continued evaporation the more deliquescent salts, such as polyhalite, kieserite, and carnallite, were deposited.

These theories account with sufficient ease for the deposition of the saline masses, but do not explain why in those days the sea water was so rich in potash and why potash is not found in other localities

where vast quantities of gypsum and common salt have been deposited. It may be that the rocks composing the shores of these lagoons were exceptionally rich in potash, and that this salt was, therefore, in a certain degree, a local contribution to the products of concentration.

Up to the present time, deposits of potash salts have not been found in this country in connection with the mines of rock salt which exist in great numbers and underlie a vast extent of territory. It is true a systematic search for potash deposits has never been made, but, as in the case of the German deposits, if they had existed to any extent in this country they would have been discovered accidentally in the mining of rock salt which has been so extensively practiced. Our geologists and agronomists, however, do not despair of the discovery of potash deposits on the continent of North America, although there is no danger of the exhaustion of the German mines for hundreds of years to come. In the interest of economy, however, it would be found that the saving in freight which would be secured by the discovery of domestic deposits would prove of the greatest advantage to the American farmer.

QUANTITY OF POTASH SALTS USED ANNUALLY.

According to the statistics of the Stassfurt mines for 1894, the last available, the quantity of crude salts raised was 727,234 tons of 2,240 pounds each, worth at the mines $2,574,805. The greater part of this product was sold in the crude state for fertilizing purposes, and high-grade compounds were prepared from the rest. The quantities of high-grade products made during that year were as follows: Potassium chloride (muriate of potash), 149,775 tons, worth $4,722,049; potassium sulphate, 23,281 tons, worth $958,736; potassium-magnesium sulphate, 14,150 tons, worth $274,694.

METHODS OF PREPARING HIGH-GRADE SALTS.

The potassium chloride is prepared by leaching the carnallite, or other crude salts containing potassium chloride, either with hot water or a hot concentrated solution of magnesium chloride in such proportions as to dissolve the potassium and magnesium chlorides but not the common salt. On cooling this solution to 70° C. and allowing it to remain for some time, the potassium chloride is deposited in a crystalline form. A second crop of crystals is also obtained by cooling the mixture to usual temperatures. On concentrating the residual mother liquor, another crystalline deposit, consisting of mixed potassium and magnesium chlorides, is obtained, which can be added to the crude salt and re-treated as above. The crystals of potassium chloride obtained by the first two crystallizations are washed, drained, dried, and packed for shipment. By repeated evaporations, crystallizations, and resolution, about 85 per cent of the potassium chloride is

finally obtained, only about 15 per cent being lost in the waste waters. Even these wastes are evaporated and sold for fertilizing purposes to nearby farmers.

Potassium sulphate is most easily prepared by treating the chlorine compounds of potash, obtained as already described, with sulphuric acid. Free hydrochloric acid is generated by this treatment, which may be collected in cold water in the usual way.

The double sulphate of potash and magnesia is made for commercial purposes from the impure kainite as it comes from the mines. A saturated solution of the crude kainite, made with water under pressure at a temperature of 250° F., will deposit the double sulphate in fine crystals on cooling.

Potassium carbonate is made from the chloride or sulphate by roasting the salts with finely divided charcoal and carbonate of lime. By this process potassium carbonate is formed, which can be extracted by lixiviation. For fertilizing purposes this salt is used chiefly for tobacco.

CHANGES IN POTASH DEPOSITS.

The deposits of potash salts are not all found at the present time in the same condition in which they were first separated from the natural brines. The strata have been subjected to the usual upheavals and subsidences peculiar to geological history, whereby their edges have been brought to the surface and exposed to solution. The dissolved brines afterwards deposited the crystallizable salts in new combinations. For instance, kieserite and the potassium chloride of carnallite were first dissolved from the deposits and there was left a salt composed chiefly of potassium and sodium chlorides known as sylvinite. In some cases there was a mutual reaction between the magnesium sulphate and the potassium chloride, and a new salt, viz, schönite, a magnesium-potassium sulphate, was produced.

The most important of these secondary products, from an agricultural standpoint, is kainite. This compound has arisen by the union of potassium and magnesium sulphates and magnesium chloride, and is formed at the borders of the layers of carnallite wherever water has worked upon it. The quantity of kainite, as may be supposed, is far less than that of carnallite, but there is quite enough of it to satisfy all the demands of agriculture for an indefinite time.

COMPOSITION OF THE PRINCIPAL POTASH SALTS.

KAINITE.

The most important of the natural salts of potash for fertilizing purposes is the mixture described above, known as kainite. In a pure state it is represented by the symbol $K_2SO_4.MgSO_4.MgCl_2.H_2O$. Its theoretical content of potash is 16 per cent. The pure salt, however, is not found in commerce. As it comes from the mines, it is

mixed with common salt, potassium chloride, gypsum, and other bodies. In general, the content of potash in the commercial kainite is about 12.5 per cent, of which more than 1 per cent is derived from the potassium chloride present. Kainite occurs in situ as a crystalline, partly colorless and partly a yellow-red mass. When ground, in which state it is usually sent into commerce, it forms a fine gray-colored mass containing many small yellow and red-colored fragments. It is not hygroscopic, and if it become moist it is due to the excess of common salt which it contains. Formerly, kainite was regarded as a potassium-magnesium sulphate, but this conception does not even apply to the pure salt, much less to that which comes from the mines. If, therefore, the farmer desire a potash fertilizer free of chlorine, he would be deceived in choosing kainite, as it may sometimes contain nearly 50 per cent of its weight in chlorides.

In many cases the chlorine content of kainite may prove advantageous, the chlorides, on account of their easy diffusibility through the soil, serving to distribute the other ingredients. By reason of the presence of common salt and magnesium chloride there is a tendency for kainite to harden into compact masses, which may be prevented by mixing it with about 2.5 per cent of its weight of finely ground dry peat.

CARNALLITE.

This mineral, the most abundant of the natural deposits of potash, is a mixture of potassium and magnesium chlorides and crystallizes with six molecules of water. It is represented by the symbol $KCl.MgCl_2.6H_2O$. The pure salt is not found in commerce, and the commercial article contains a quantity of potassium and magnesium sulphates and other bodies. Carnallite is the chief source of the muriate of potash (potassium chloride) which is found in commerce. The commercial carnallite has slightly less potash than kainite, the mean content being about 9.9 per cent. It occurs in characteristic red-brown masses, and on account of its highly hygroscopic nature it should be kept, as far as possible, out of contact with moist air and should not be ground until immediately before using.

POLYHALITE.

Polyhalite is a mineral occurring in the Stassfurt deposits, and consisting of a mixture of potassium, magnesium, and calcium sulphates, crystallizing with a small quantity of water. On account of being practically free of chlorides, this mineral would be an ideal natural fertilizer for tobacco and vineyards, but unfortunately it does not occur in sufficient quantities to warrant the expectation of its ever being an important article of commerce. It is found only in pockets, or seams, among the other deposits, and there is no assurance, on finding one of these pockets, that it will extend to any great distance. The composition of the mineral is represented by the formula

$K_2SO_4.MgSO_4.(CaSO_4)_2.H_2O$. The percentage of potash in the mineral is 15.62.

KRUGITE.

This mineral occurs associated with polyhalite, and differs from it only in containing twice as much gypsum (calcium sulphate). As it comes from the mines it is frequently mixed with a little common salt. The percentage of potash in the commercial article is about 10.05. This salt, as the preceding one, also exists in limited quantities, and is not likely to become an important article of commerce.

SYLVINE.

This salt is an alteration product of carnallite, and is practically a pure potassium chloride. It is found only in limited quantities and does not have any great commercial importance.

SYLVINITE.

Considerable quantities of this mineral have been mined in recent years, and it is composed of a mixture of common salt bearing large quantities of potassium chloride and some other bodies. It was probably formed by the drying up of a saline mass in such a way as not to permit a complete separation of its mineral constituents. Its content of potash, when mined, is about 23 per cent.

KIESERITE.

This mineral is essentially a magnesium sulphate, and does not necessarily contain any potash salts. Under the name of kieserite, however, or bergkieserite, there is mined a mixture of carnallite and kieserite which is a commercial source of potash. As delivered from the mines the mixture contains only about 7 per cent of potash.

SCHÖNITE.

Among the Stassfurt deposits there occurs in small quantities a mineral, schönite, which is composed of the sulphates of potassium and magnesium. On account of the paucity of the mineral it has not much commercial importance, but when kainite is washed with water the common salt and magnesium chloride which it contains, being more soluble, are the first leached out, and the residue has approximately the composition of the mineral schönite. The percentage of potash in the commercial article is about 27. On account of its low content of chlorine, it is especially valuable for the fertilization of tobacco and vineyards.

MANUFACTURED COMPOUNDS.

Of the manufactured salts which are sold for fertilizing purposes, the sulphate and carbonate of potash are the most important.

Several grades of potassium sulphate are sold for fertilizing purposes. Some of them are quite pure, containing about 95 per cent of

pure sulphate. The percentage of potash in these high-grade salts often approximates 50.

Potassium-magnesium carbonate is considered to be one of the best potash salts for use in fertilizing tobacco. It has a percentage of potash varying from 17 to 18. The compound is dry, not hygroscopic, and, therefore, when once ground is always ready for distribution in the field. It is especially serviceable for all intensive cultures where it is feared that chlorides or sulphates will prove injurious.

The mean composition of the various salts mentioned is shown in the following table:

Constituent.	Kainite.	Carnallite.	Polyhalite.	Krugite.	Sylvinite.	Kieserite.	Schönite.	Potassium sulphate. High grade.	Potassium sulphate. Low grade.	Potassium magnesium carbonate.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Potassium sulphate	21.3	--------	28.90	18.60	6.97	--------	50.40	97.20	90.60	--------
Magnesium sulphate	14.5	12.10	19.93	14.70	4.80	21.50	34	.70	2.70	--------
Magnesium chloride	12.4	21.50	--------	--------	2.54	17.20	--------	.40	1	--------
Potassium chloride	2	15.50	--------	--------	30.55	11.80	--------	.30	1.60	--------
Sodium chloride	34.6	22.40	--------	1.50	46.05	26.70	2.50	.20	1.20	--------
Calcium sulphate	1.7	1.90	45.18	61	1.80	.80	--------	--------	--------	--------
Water	12.7	26.10	5.99	4.20	7.29	20.70	11.60	.70	2.20	25
Alumina	.8	--------	--------	--------	--------	--------	--------	--------	--------	--------
Undetermined	--------	.50	--------	--------	--------	--------	--------	--------	--------	--------
Insoluble	--------	--------	--------	--------	--------	1.30	--------	.20	.30	--------
Potassium carbonate	--------	--------	--------	--------	--------	--------	--------	--------	--------	35 to 40
Magnesium carbonate	--------	--------	--------	--------	--------	--------	--------	--------	--------	33 to 36

OTHER SOURCES OF POTASH.

The primary sources of potash, such as the original feldspars containing this element and the mineral deposits formed therefrom, are not the only stores on which the farmer may draw for supplies of this valuable material. It has already been seen that the straw of cereals and leguminous crops affords an ash rich in potash, and the manurial value of this refuse depends to a certain extent on its content of this ingredient. Other organic materials, products of agriculture, such as tobacco waste, cotton-seed hulls, the ash of woods and other terrestrial plants, residues of beet-sugar factories and wineries, and stall manures all contribute potash fertilizers to the soil.

TOBACCO STEMS.

The stems and stalks of tobacco, which are waste products in manufacture, as has already been noted, are rich in potash. These stems give about 15 per cent of ash, which may contain as high as 8 per cent of potash. It is not, however, advisable to burn the tobacco waste in order to obtain its fertilizing ingredients. In combustion,

the nitrogenous constituents of the waste, which are also valuable fertilizers, are lost, although it is true that both the potash and phosphoric acid become more immediately available after incineration. In order to promote the absorption of the fertilizing ingredients of tobacco waste, it should always be finely ground before applying it to the soil or mixing it with other fertilizing materials.

COTTON SEED.

The potash content of cotton seed is one of considerable importance from a fertilizing point of view. It is customary, in many localities, after the separation of the hulls from the seed, to burn the former and use only the ash for fertilizing purposes. Cotton-seed hulls contain a less percentage of mineral matter than the kernels, but still afford about 3 per cent of ash to 7 per cent for the meal after the extraction of the oil. If the percentage of potash in the kernel and hull be determined before the extraction of the oil, the difference in quantity is not so great. The percentage of potash in the ash of the hulls is about 23, while in the ash of the meal it is slightly higher. By reason of the destruction of the nitrogenous constituents of the hulls in burning, the propriety of this process is questionable from an economic point of view, although, as was stated in the case of tobacco waste, both the potash and phosphoric acid of the ash become more quickly available after burning.

ASH OF WOODS.

The importance of wood ashes as a fertilizing principle has long been recognized, and the content of potash therein is one of the principal points to be considered in determining their fertilizing value. Unleached hard-wood ashes contain about 5.5 per cent of potash, 2 per cent of phosphoric acid, and 34 per cent of lime. The potash in wood ashes exists chiefly in the form of carbonate. In leaching to obtain lye for soap-making purposes, the potassium carbonate is mostly removed. The leached ashes, however, retain a high fertilizing value, both on account of the small quantity of potash which remains and also for the lime and phosphoric acid which they contain. There is no uniformity of composition in the wood ashes which are offered for sale for fertilizing purposes. It is necessary that each cargo be carefully sampled and analyzed in order to determine its fertilizing value. Farmers, in purchasing wood ashes, should secure a reliable certificate of their composition, showing at least the percentages of potash and phosphoric acid which they contain. The application of wood ashes to a soil not only supplies valuable fertilizing ingredients, but also, in the case of a stiff soil or one deficient in lime, exercises a marked ameliorating effect in respect of its physical condition. Land treated liberally with wood ashes becomes more amenable to culture, is readily kept in good tilth, affords good drainage

in wet, and retains moisture in dry, seasons. Injurious iron salts which are sometimes found in wet and sour lands are either rendered insoluble by the ash and thus innocuous or even changed to beneficial forms. A good wood-ash fertilizer, therefore, is usually worth more than would be indicated by its commercial value based upon its content of potash and phosphoric acid.

FORMULA FOR POTASH FERTILIZERS.

To one who has carefully read the foregoing pages it is hardly necessary to say that any fixed formula for a potash fertilizer is of little value. Where the field requires only an application of potash to complete a well-balanced ration for the crop, it is extremely easy to apply the appropriate quantity of the crude or concentrated potash salt. In general, it may be said that it is more economical to apply each one of the three essential plant foods separately as needed rather than to combine them into a single mixed fertilizer which shall contain the proper proportions of each ingredient. On the other hand, it may be urged in favor of a mixed fertilizer that it can be purchased already prepared and one application will be sufficient. When it is considered, however, that not only the demands of the soil but the nature of the crop are to be regarded, it is easy to see that the intelligent farmer who is aware of the needs of his fields is able to control the rations of the crops more accurately and economically by supplying the fertilizing ingredients separately. If, however, it be desired to apply a mixed fertilizer, it may either be made on the farm from the ingredients or purchased already prepared with a reliable guaranty of composition. As an illustration of the method of preparing a mixed fertilizer, it may be said that if one is required containing 4 per cent of potash, and the ordinary commercial kainite be the salt from which it is to be compounded, it will require 640 pounds of the commercial kainite to give the required quantity in a ton. In like manner, any desired percentage of potash from the ingredient at hand may be computed when the percentage of potash in that ingredient is known.

KINDS OF SOIL REQUIRING POTASH FERTILIZERS.

Whether or not a given soil requires the addition of potash to secure its maximum fertility may be determined either by experiment or analysis. Whenever the total quantity of potash soluble in hot hydrochloric acid falls below 0.12 per cent, there is reason for assuming the need of potash fertilizers. The nature of the crop is also to be taken into consideration, since a soil having enough potash to produce a fairly good yield of cereals might have too little of it to yield average harvests of tobacco or beets.

Soils reclaimed from marshes and vegetable soils in general are deficient in potash. The light sandy soils used for growing early

vegetables, sweet potatoes, and melons are also uniformly deficient in potash. In both of these classes of soils the potash content soluble in hydrochloric acid often sinks to as little as 0.05 per cent or less. As the content of clay in soils increases it will be found, in general, that there is a corresponding increase in potash, since both clay and potash are derived from the decay of silicates. But even in such soils, where chemical analysis reveals an apparently satisfactory quantity, the addition of small quantities of soluble potash salts supplies the conditions for a marked increase in fertility. The progressive farmer, therefore, will not fail to test the requirements of his field for potash by instituting small experimental plats which will give unbiased answers to his inquiries.

CONDITIONS NECESSARY TO SECURE THE BEST RESULTS IN THE USE OF POTASH FERTILIZERS.

The fertility of a field, in given meteorological conditions, is measured not by its most abundant but by its weakest fertilizing principle. The essential condition of the good results of potash when added as a fertilizer is that it completes a well-balanced ration. Only when the other necessary ingredients of the plant ration are present in proper proportions can it be expected to secure, from added potash, the maximum benefits. Unfortunately, this primary condition is too often neglected by our farmers, and so in one case we find them using a material which is already abundantly provided, or failing to secure its effects by neglecting the absence of its necessary coworkers. The contractor who should undertake to build a house and supply to his workmen nothing but saws is no more erratic than the farmer who would grow his crops with nothing but potash.

LIME AS AN ADJUNCT OF POTASH.

It has been abundantly demonstrated that the beneficial effects of potash in the soil are greatly affected by lime. Lime in this respect plays a double rôle, serving both as an indispensable food of the plant and as a most necessary adjunct in those decompositions induced by biochemical action and without which plant nutrients could not assume their natural functions. It seems quite certain that in the decomposition of manurial salts under the combined influences of bacterial and biochemic activity, the separated acids would exert a fatal influence on vegetation were they not at once neutralized by an appropriate base. The lime, existing chiefly as carbonate, supplies this convenient base. In other words, the plant juices, being acid, absorb the decomposed base with greater avidity than the free acids, and as a result there is an excess of acidity of a mineral nature produced in immediate contact with the most tender parts of the roots. The great function of the lime in the soil, aside from its mechanical effects, is, therefore, to neutralize this free acid and protect the plant

from its injurious effects. It is certain that much of the acid thus produced is unnecessary for plant growth and is permanently withheld from entering the vegetable organism. The nitric and phosphoric acids are retained only long enough to permit of their proper absorption, while the carbon dioxide which is produced escapes to enrich with this constituent the soil gases or to finally find its way into the ambient atmosphere.

The production of organic acids, as a result of vegetable metabolism, also renders unnecessary much of the mineral acids with which the bases found in plants are combined in the soil. The presence in a soil of a large quantity of a base which can neutralize these rejected acids is therefore an absolute condition of vigorous plant growth.

Further, it must not be forgotten that the addition of potash salts to the soil causes, to a certain extent, a loss of lime. In the mutual reactions which take place in the soil, alkaline silicates are formed from the sulphates and chlorides of the alkalies. A quantity of lime corresponding to these is converted into sulphates and chlorides, and is removed by the usual processes of leaching. By computation it is found that the addition of one hundred parts of kainite to a soil will cause a loss of at least forty parts of lime, aside from other quantities which may enter the crop or be changed in such way as to be no longer valuable. It is therefore safe to assume that for every pound of crude potash salt added to the soil there will be a loss of a corresponding weight of lime. A judicious addition of lime, therefore, to a lime-poor soil is a necessity when the best results of adding potash are to be secured.

The addition of potash salts to a heavy soil, that is, one having an excess of clay, tends often to make it more impervious and impermeable. In such cases their use, even when the soil demands them, may be more injurious than beneficial. These unfavorable effects may be completely prevented by the generous application of lime.

EFFECT OF POOR DRAINAGE.

Poor drainage is sufficient to neutralize all the good effects which may be produced in a field by the application of needed potash. In this case, as with other fertilizing materials, the proper culture and aeration of the soil are imperative. To apply fertilizers to a field saturated with water and deprived of means for its outflow is only a mark of poor judgment and a waste of good money.

THE BEST KINDS OF POTASH FERTILIZER.

What kind of potash fertilizer is best in any given case depends on two factors, viz, economy and the requirement of the crop. In localities where freights are low, it is evident that the crude salts, as they come from the mines, are the most economical for all crops, save such as

tobacco, grapes, etc., which require a special compound. In case the salt has to be carried to a great distance, and at high rates of freight, it is advisable to make use of the concentrated compounds. The kainite of commerce contains about 12.5 per cent of potash, while a high-grade sulphate will have 50 per cent. One ton of the sulphate will therefore contain as much potash as 4 tons of kainite.

The actual cost of potash per unit is readily calculated in each case. If the kainite cost $10 per ton, including freight, the farmer can afford to pay $40 for the sulphate, and will save the handling of 3 tons of material. In all cases the price per ton of the salt should be considered in connection with its content of potash. With the exception of tobacco, grapes, and a few other crops of minor importance, the form of combination of the potash salt is not important. For tobacco, the salts containing potash as chloride are to be excluded. Sulphate and carbonate of potash are the salts which the tobacco growers should apply. In some cases, for intensive culture in gardens or pots, it is advisable to use the most concentrated plant foods. In these instances the cost of the fertilizer is of little importance. Two salts representing a highly concentrated food are the phosphate and nitrate of potash. The commercial potassium phosphate employed for fertilizing purposes contains from 36 to 38 per cent of soluble phosphoric acid and from 26 to 28 per cent of potash. The pure salt, K_2HPO_4, contains 40.81 per cent of phosphoric acid and 54.01 per cent of potash.

Since most crops require a larger quantity of potash than of phosphoric acid, it is seen that the use of commercial potassium phosphate would entail a loss of the former in order to secure a sufficient quantity of the latter. For instance, sugar beets require three times as much and cereal crops nearly twice as much potash as phosphoric acid. If, therefore, this highly concentrated salt be employed for intensive culture, it should be supplemented by a considerable quantity of high-grade potash salt containing no phosphoric acid. If, however, the salt be applied to a soil rich in available potash and poor in phosphoric acid, the above objection to its use would not obtain.

Saltpeter (potassium nitrate) is another example of a concentrated plant food. For intensive culture, a mixture of potassium phosphate and nitrate is an ideal ration, when it is desired to supply in a highly available form the three most essential elements of plant food. The high cost of saltpeter confines its use solely to experimental plats. Even when mineral salts, in the forms in which they are found in the ash, are supplied to plants, it is doubtful whether they play any important rôle in vegetable growth without suffering decomposition. It is certain that the silicates of the soil containing potash are decomposed by the biochemical activity of vegetable life, and there are many reasons for believing that when phosphate of potash is applied as a

fertilizer and is afterwards found in the ash, it has, in transit, suffered a complete decomposition and recomposition under the powerful agencies of vegetable metabolism.

INJURIOUS SALTS.

Experience has shown that certain crops are unfavorably affected by the use of crude potash salts, and that the cause of this injury resides in the potassium and other chlorides which they contain. This injury does not consist in a diminution of the quantity of the crop, but in its quality. The tobacco plant is the most striking example of this influence. When tobacco is fertilized with crude potash salts or with the muriate, the chlorine contained therein is absorbed in large quantities and, on burning, an ash is obtained showing an excess of chlorides. By reason of the easy fusibility of the chlorides, the burning properties of the tobacco are greatly impaired. Some experimenters claim that an excess of sulphates in the ash is also an injury, but authorities are not agreed on this.

In like manner, the application of chlorides to vineyards tends to diminish the content of sugar in the grapes, and thus impairs the quality of the wine.

In the case of sugar beets, the use of highly chlorinated fertilizers is of doubtful propriety, save on sandy soils, where kainite may be most freely used without fear of injury.

Potatoes also may have their content of starch somewhat diminished by a too free use of crude potash salts containing large quantities of chlorine.

On the other hand, it is quite certain that the kainite, which is comparatively poor in chlorine, may be safely supplemented by carnallite, very rich in chlorine, for all cereal and leguminous crops, while for tobacco and all sugar or root starch crops it is safer to employ the salts poor in chlorine.

PRESERVATION OF STALL MANURE.

The losses which stall manure suffers when exposed without care for its conservation are well known. It is estimated that, in general, where no precautions are taken nearly one-third of the humus-forming material in stall manure is lost before it reaches the field. For a full-grown steer or horse, this means at least a loss of 2,000 pounds of humus during a year. Of the nitrogenous substances, in similar conditions, one-quarter is lost, corresponding to at least 200 pounds of chile saltpeter a year for each horse or cow. Calculated to a money value, these figures mean a loss of over $5 a year for each full-grown animal.

These losses may be, in a great measure, prevented by covering the stall manure with layers of earth or with earth mixed with gypsum or crude potash salts. Earth covering alone, however, prevents very

little of the loss in organic substance, although quite efficient as a nitrogen preserver.

When stall manures are sprinkled or mixed with kainite, the fermentative processes are partially arrested, the manure is preserved in a fresh state, there is little or no loss of organic matter, and the nitrogen content of the mass suffers but little loss.

By reason of the fact, however, that the stall manure is preserved from decay, it is evident that it can not give its maximum benefit to the first crop grown. If, for instance, the first crop grown after applying the fertilizer be potatoes, and the next a cereal, such as wheat or barley, the maximum effect of the application of the stall manure will be felt in the second crop. When an immediate effect is desired, therefore, it is better to preserve the stall manure by means of superphosphate or a covering of earth, while if the secondary effect is of more importance, the preserving material should be kainite.

Practical farmers should not forget these facts in selecting materials for preserving stall manure. Kainite, however, is inferior to carbon disulphide and sulphuric acid as a preserving agent.

Further, experience has shown that stall manures preserved with kainite are far more effective on light than on heavy soils. In a light, sandy soil stall manures preserved with kainite give a far better result than when other means of conservation are employed. In light soils the decomposing influences of aeration and attendant fermentation go on much more rapidly than in stiff and impervious soils, and for this reason the practically undecomposed stall manures which have been preserved by kainite rapidly undergo fermentation and yield to the plant those elements best suited to its rapid evolution.

It happens also that sandy soils are, as a rule, deficient in potash, and therefore the kainite used as a preserving material finds a direct application as a plant food in a locality where it is most needed.

Experience has further shown that basic phosphatic slags, which are cheaper than superphosphates, are peculiarly well suited to light, sandy soils, and this fact renders the use of superphosphate as a preserver of stall manures destined for sandy soils less important. The practical farmer will see, from these facts, that for such soils he will receive the largest returns by the application of stall manure preserved by kainite, in conjunction with basic phosphatic slags.

It is further to be noted that the preserving influence of the kainite is destroyed when the manure is diluted by incorporation with the soil, and that the activity of the ferments, which had been suspended by the application of the kainite, is restored and invigorated by mixing with a light soil, affording a most abundant aeration.

THE PROPER TIME AND METHOD OF APPLYING POTASH FERTILIZERS.

In the application of potash fertilizers, the farmer must take into consideration, not only the character of the soil, but also the nature

of the crop and the meteorological conditions likely to obtain. In general it may be said that where excessive rains are not expected it is better to apply potash fertilizers in the autumn. In certain soils, potash, as well as other salts, such as sodium chloride and chile saltpeter, produce a kind of cementation or hardening which greatly interferes with the subsequent circulation of air and moisture and with the distribution of the rootlets of the growing crop. This unfavorable condition is brought about by the hygroscopic nature of the added substances, whereby each particle of salt attracts a sufficient quantity of moisture to thoroughly wet the particles of soil in immediate contact therewith. On drying, especially in soils containing certain proportions of clay and sand, a true mortar or cement is produced. Certain soils may become so hard by this means on the addition of large quantities of saline materials as to resist the blows of a pick. To such soils potash salts should never be added in the spring, but only in the autumn, whereby the cementation produced is usually completely disintegrated by the winter's frosts. The evil effects mentioned above may also be prevented in most cases by the liberal use of lime, which, by reason of its well-known property of forming compounds less likely to produce compact particles, will hold the soil in a porous state.

It is advisable, therefore, to always use lime in conjunction with large quantities of potash, especially in soils having a tendency to become compact and impervious. In intensive culture it is safe to use as much as two tons of kainite per acre, if double that quantity of lime be added at the same time.

Where only small quantities of potash are applied, as, for instance, a quantity representing 30 or 40 pounds of pure potash per acre, there is not much danger in applying it in the spring. It must be remembered, however, that potash salts in direct contact with seeds exert a retarding influence on germination by reason of their tending to absorb moisture, and probably also from a slightly corroding or germicidal effect which they may produce. Care should therefore be exercised in applying these salts to prevent, as far as possible, their direct action on seeds of feeble vitality. In general it is advisable, however, in the spring, wherever practicable, to apply the fertilizer from two to four weeks before planting the crop, and to have it thoroughly distributed through the soil by the plow and harrow. As a rule, top-dressing with potash salts is not to be recommended, except for meadows and lawns, and sometimes for the spring fertilization of cereals. In some cases, where the fertilizer has not been incorporated with the soil by previous cultivating, top-dressing at the time of planting or immediately thereafter is advisable.

Top-dressing is also necessary in those cases where it is not advisable to apply the whole of the fertilizing material at once. Especially in the cultivation of sugar beets and tobacco is it desirable to apply a final portion of the potassic fertilizer in the earlier periods of cultivation. Top-dressing with potash salts, it is easy to see, becomes

useless unless the material is carried down to the rootlets by heavy rains or deep cultivation. In top-dressing, the salts should be applied in as fine a state of subdivision as possible. Good judgment and a wise adaptation to local conditions are as necessary in potash fertilizing as in other agricultural operations, and any attempt to fix rules for guidance in all cases would be useless and misleading.

INDIRECT EFFECTS OF POTASH SALTS.

In the foregoing pages the uses of potash as an essential and indispensable plant food have been briefly noted. It has been seen that without the aid of this food no plant can make a normal growth or reach maturity. There is no other mineral substance or combination of such substances that can act as an acceptable substitute for it. There are, however, many indirect effects of potash salts which must not be overlooked. Some of these have already been noted, as, for instance, the tendency in certain cases to form concrete masses and to retard the germination of seeds of low vitality. There are other indirect effects of these salts which are not injurious, but, on the contrary, advantageous and worthy of notice.

CONSERVATION OF SOIL MOISTURE.

The hygroscopic nature of these salts, already noted, serves to keep the soil moist, and thus, in seasons of drought, it may help secure for the crop a more abundant supply of water. This property is fully illustrated by determining the moisture in two samples of the same soil, one with and one without potash salts. In data secured in one instance, at different times, the quantities of moisture found in the two samples were as follows:

Date.	With kainite.	Without kainite.
	Per cent of moisture.	*Per cent of moisture.*
March 18	15.3	15.2
June 1	8.5	1.8
August 1	5	1.3
October 18	13.3	1.9

From the above table the marked difference in moisture in the two samples during the summer and autumn is quite instructive. It is true that a soil impregnated with kainite would give up its moisture less readily to a growing plant than one free of that salt, but there is no doubt that a soil containing kainite, with 13 per cent moisture, would be able to supply water to a plant more readily than a soil free of kainite and containing only 2 per cent of moisture.

INFLUENCE ON DECOMPOSITION OF MINERALS.

The influence which potash salts exert on mineral matters left in the soil has already been noticed. By the double decompositions

which they form with the lime and other bases locked up in silicates, they tend to promote the decomposition of those bodies, and thus to add large quantities of mineral matters, including potash, to the available stores of the soil. This favorable action of potash salts is one which should be considered in making a summary of the indirect action of potash fertilization. This solvent action is not shared by potash salts alone, but soda salts may also secure, to a certain extent, the same result. For this reason, it is quite probable that the claims which have been made by many, to the effect that soda may replace potash in agriculture, have been based on the solvent action of the soda setting free additional quantities of potash which have become available. This solvent action, however, may not in all cases be advantageous, inasmuch as the decomposition may be so extended, when combined with the absorption of the separated bases by the plants, as to leave the acids with which the bases were originally combined in a free state in the soil. In this way, unless an excess of calcium carbonate be present, the free acids may exert an injurious effect.

PROTECTION AGAINST FROST.

It has been noticed that the liberal application of potash fertilizers, especially the crude salts, lessens to a certain extent the injuries which the crop may suffer from frost. This is an item of considerable importance, especially in the case of tobacco, which is often greatly injured by frost in the early autumn. The cause of the protection which kainite, for instance, offers to plants against frost is found in two sources. In the first place, on account of the hygroscopic nature of the salt the moisture of the soil is more securely held and there is a less rapid evaporation. One of the prime conditions of the formation of frost is a rapid evaporation and consequent cooling of the surface of the soil. Anything which prevents this, of course, tends to diminish the intensity of the frost. In the second case, the presence of a potash fertilizer produces a more luxuriant vegetation, and thus secures a more perfect cover of the soil, affording in this manner a less rapid evaporation. These two causes combined undoubtedly have a tendency to diminish the danger from frost to which a crop may be exposed.

RETARDATION OF NITRIFICATION.

The addition of large quantities of potash salts to a soil has a tendency in certain cases to retard the process of nitrification, which, as is well known, does not proceed as vigorously in solutions of certain salts. The potash salts in this case exercise something of the same influence, as will be mentioned below, in acting as a germicide. It is not difficult to see that in most cases this action would not be prejudicial. On the contrary, where there is a tendency to the overproduction of nitric acid by a too vigorous action of the ferments, the presence of potash salts would be beneficial. As a rule, however, it must be confessed that this retardation of the process of

nitrification is to be avoided as much as possible, and this can be secured by a moderate use only of potash fertilizers.

POTASH SALTS AS INSECTICIDES AND FUNGICIDES.

The property possessed by large quantities of potash salts of preventing the ravages of insects and the occurrence of certain diseases has long been noticed. It has been shown that in the case of cotton the leaf blight is largely if not entirely prevented by the free use of kainite, and at the same time the yield of cotton is increased. It is claimed by some entomologists that potash in large quantities is effective against plant lice of all kinds and against any naked larvæ and the wire worms on potatoes and cabbages. Its greatest usefulness as an insecticide is said to be with those pests that live in the ground and around the roots of the plants. The retarding effect which potash salts have on germination is more than compensated for by their effect upon cutworms and other insects which infest plants at the period of their germination. It is believed that kainite is the best form in which potash salts can be used when their insecticidal or disease-preventing properties are to be considered. It must be remembered, in connection with this statement, that it is not the universal experience of entomologists that kainite is a successful insecticide. It probably varies in its action, and in all cases where used for insecticidal purposes it must be applied in larger quantities than would be necessary for its merely manurial value. The weight of authority, however, is perhaps in favor of the use of kainite for the purpose mentioned above. Attempts to control or prevent peach yellows by the use of kainite have shown it to have no value for that purpose.

SUMMARY.

1. The potash used in fertilizers and found in the soil has been derived from the decay of minerals containing it as an ingredient, and chiefly from feldspars.

2. During the progress of weathering, a portion of the potash in original rocks becomes soluble and is lost by lixiviation. As a rule, about 25 per cent of the potash finds its way by this means into the streams and seas.

3. There is usually a less percentage of potash in the finer particles of soil than in the coarser particles, and this is due to the fact that the solvent action of water is more strongly exerted upon the finer particles.

4. The potash is quite evenly distributed both in the soil and subsoil, there being only a slightly greater proportion in the deeper layers, doubtless due to the fact that they have not been so thoroughly leached.

5. The solubility of potash in the soil is very different for different solvents, being the least for the weak organic acids and greatest for the strong mineral acids. Hot hydrochloric acid extracts from the

soil about 20 per cent of its total potash content, which is about thirty-two times as much as is removed by a 1 per cent citric acid solution.

6. A fertile virgin soil contains about 2 per cent of total potash, or about 70,000 pounds per acre taken to the depth of 1 foot. A crop removing 50 pounds of potash a year could be grown consecutively for about one thousand four hundred years on such a soil before exhausting all the potash which it contains.

7. The soil retains a certain quantity of fertilizing material with such tenacity as to render it practically impossible for plants to withdraw the whole of it, thus protecting the future against the rapacity of the present.

8. The quantity of potash removed by various crops per annum varies greatly. The largest quantities are removed by beets, and the smallest quantities by cereals and cotton. Beets may remove as much as 100 pounds per acre, cereals about 30 pounds, and cotton about 23 pounds for the average crops as produced in this country. In Germany, beets grown for forage remove often over 200 pounds of potash per acre from the soil, clover hay about 74 pounds, and tobacco the same quantity.

9. Tobacco contains a larger proportion of potash than any other common crop, viz, about 40 parts per thousand of the dry leaves. Forage beets contain 35, potatoes 20, sugar beets 18, clover hay 19, beans 13, and cereals 5 parts per thousand.

10. There is about four times as much potash in the straw of cereals as in the grains, while in peas and beans the proportion is about as two to one.

11. A soil which yields about 0.01 per cent of potash to a 1 per cent citric acid solution and contains about 0.30 per cent soluble in hydrochloric acid does not usually need a potash fertilizer.

12. The potash salts which supply the commercial potash fertilizers of the world have been deposited as the result of the evaporation of saline lakes charged with potassic materials.

13. The commercial potash of the world is derived almost exclusively from the neighborhood of Stassfurt, in Germany. The quantity of crude salts annually mined is about three-quarters of a million tons, worth nearly three million dollars.

14. The high-grade commercial salts used for fertilizing purposes are manufactured from the crude salts, and are to be preferred when shipments are made to great distances and at high rates of freight.

15. The principal crude potash salts used for fertilizing purposes are kainite, containing 12.5 per cent of potash, and carnallite, containing 9.9 per cent.

16. Tobacco waste, cotton-seed hulls, and wood ashes also furnish important quantities of potash for fertilizing purposes.

17. Recovered marsh or swamp lands and lands containing large quantities of sand need, almost universally, potash fertilizer. The percentage of potash in soils usually rises with their content of clay.

18. The maximum effect from fertilization with potash is secured only when other plant foods are supplied in such a way as to make a well-balanced ration, and where proper methods of culture are employed.

19. Lime is an important adjunct to potash fertilization, and, as a rule, should be added to a soil in large quantities wherever potash is applied.

20. The best kind of potash fertilizer is determined by local conditions, freights, and the nature of the soil and crop. Fertilizers containing considerable quantities of chlorine should never be applied to vineyards and tobacco fields.

21. In intensive pot or garden culture, where highly concentrated plant foods are desired and where the cost of the fertilizer is unimportant, potash may be applied in the form of phosphate or nitrate.

22. In some soils potash salts, in common with other saline bodies, produce injurious effects by reason of their hygroscopic nature, attracting moisture and, on drying, producing a cementation of the soil, which renders it impervious to water and impenetrable by the rootlets of plants.

23. Crude potash salts can be applied with benefit in the preservation of stall manure, but their value for this purpose is perhaps overestimated.

24. Potash fertilizers should, as a rule, be applied in the autumn, or at least from two to four weeks before planting, and should be thoroughly worked into the deeper part of the soil in order to come into contact with the rootlets of the plant.

25. The germination of seeds, especially if they have a low vitality, is retarded by bringing them into direct contact with potash salts.

26. The application of crude potash salts to a soil which is not easily cemented may be useful during a dry season by reason of their power of attracting and holding moisture.

27. Potash salts favor the decomposition of mineral particles in the soil, and thus tend to add to the stores of plant food therein.

28. The application of crude potash salts to the soil tends to protect the crop from frosts by preventing the too rapid evaporation of moisture and by producing a more luxuriant foliage.

29. The too abundant application of potash to the soil may become injurious by reason of the retardation of the process of nitrification which it produces.

30. Crude potash salts, especially kainite, when added abundantly to a soil, are said to act, to a certain extent, as an insecticide or a preventive of disease, and when mixed with stable manure act as a preservative by checking the activity of the denitrifying ferments.

31. It is impracticable to give formulas for the preparation of fertilizers containing potash, since both the quantity of potash to be used and the form in which it should be applied are determined by local conditions, which can not be taken into account in the preparation of directions for the use of fertilizers.

SOME COMMON POISONOUS PLANTS.

By V. K. Chesnut,

Assistant, Division of Botany, U. S. Department of Agriculture.

GENERAL REMARKS.

The plants commonly looked upon as poisonous are those which through general experience, history, or tradition have long been known to produce some ill effect upon animal life. The number recognized in any country tends, therefore, to be proportional, not only to the variety of its flora, but also to the antiquity of its civilization; and the popular estimation of the virulence of any particular plant depends in great measure upon the number of its victims as well as upon the rapidity and violence of its effects. The literature of these plants is filled with allusions to species growing in Hindostan and the Greek and Roman provinces, and history teaches how certain species, such as the peach (for its pits and leaves) and the hemlock, came to be especially dreaded by the ancients on account of their extensive use in putting state criminals to death. The literature of Europe contains the names of over three hundred and fifty plants which, in that quarter of the globe, have been known to produce ill effects upon man or animals, while in North America there are only a few which have been generally recognized as poisonous, and these grow mostly in the eastern and more thickly settled half of the continent. Very little is known concerning those which are native to the region west of the Mississippi River. Those chiefly reported in the newspapers throughout the United States are poison ivy, the so-called "wild parsnip," and certain fleshy fungi commonly known as toadstools. It is true, however, that a considerable number of plants should, at least provisionally, be ranked as poisonous in the flora of a comparatively new country, such as the United States. It is a fair presumption that every plant is poisonous which is very closely related to a species recognized as virulent in other countries. It is prudent, also, to suspect all plants popularly supposed to produce ill effects, regardless of the results of analyses hitherto made, for the chemical and biological investigation of plant poisons is as yet too little advanced to furnish conclusive data in all cases.

There are several causes which tend in the United States and elsewhere to an underestimate of the number of poisonous plants.

In the absence of statistics, objection is made to an increase in the number of ill-reputed species for æsthetic reasons, and on the ground that plants exist for consumption by animals, and can not therefore be poisonous. These ideas are wholly without scientific foundation and are deplorably misleading; indeed, instances might be cited where men have nearly sacrificed their lives in attempting to verify the supposed innocent nature of certain plants which authorities have declared harmless. Yet, it is impossible to refute these ideas all at once, on account of the apparent uncertainties and contradictions which the subject presents to the novice. A full acquaintance, however, with the preparation of drugs and with their action upon animals removes many of these uncertain factors.

It is characteristic of organisms, both plant and animal, that their elements are slowly but constantly undergoing chemical changes. During health these changes take place naturally and afford heat and nourishment. In sickness they take place with greater or less rapidity, according to the chemical nature of the compounds involved in the disease, and are modified by the proper application of drugs. Poisons differ from foods and medicines mostly in the rapidity, but also to some degree in the character, of the chemical changes which they produce. They are therefore to be considered as substances which are unstable or extremely liable to change. This fact has always been recognized to a limited extent by experts, but it has only somewhat recently become known that certain plant poisons are destroyed even by the addition of alcohol, or by simply heating to a temperature of 60° C. Thus, the poison is subject to destruction in the process of analysis. Further than this, it may not exist in the part analyzed; and, moreover, the amount varies greatly in the same species, according to climate and the conditions of soil and season.

Again, the susceptibility of animals differs greatly. Some are little, if at all, affected by poison taken in quantities which, judging from the effects produced on others, should cause instant death. This may be due to differences in physiological functions, in character of food, or in natural or acquired habits. It is well known, for example, that large quantities of certain poisons, such as strychnine, opium, and arsenic, can be taken with impunity by man after the long-continued use of small doses. May not this endurance of certain animals be explained on analogous grounds? Other factors which determine differences of action are age, sex, temperament, and idiosyncrasy; the latter explains why strawberries are poisonous to some individuals.

In the widest sense, therefore, all those plants should be classed as poisonous which have ever produced ill effects accidentally, and not those alone which the combined knowledge of the botanist, the chemist, and the animal expert has proved to be such. Especially should this view be taken in a new country, and in the case of plants likely to tempt the appetite. By this cautious attitude the dangerous plants

can be ascertained and antidotes be determined without repeated sacrifice of life and property.

Chemistry has already rendered much service in explaining the obscure behavior of some of these poisonous plants, and it is believed that recent discoveries will point out the true character of some species which have hitherto baffled all scientific progress.

POISON IVY.

The poison ivy (*Rhus radicans*) occurs abundantly throughout the United States east of the Great Plains, and in greater or less abundance throughout the less arid regions of the West, with the exception of California, where it appears to be entirely wanting in all localities. It grows everywhere in the open brush, in ravines, and on the borders of woods, and it spreads along roadsides and cultivated fields from seeds carried by crows and other birds which feed upon its fruit. It is generally a climbing vine, but if no support is at hand it either trails along the ground or sends up short vertical shoots. (Fig. 24.)

FIG. 24.—Poison ivy (*Rhus radicans*).

Besides one near Western relative, which is almost as poisonous, there are no other plants which resemble it closely excepting the nonpoisonous box elder, the leaves of which bear a striking resemblance to those of the ivy. It is only in its seedling stage, however, and when growing along hedges, that the box elder could be taken for ivy. The Virginia creeper, also nonpoisonous, is sometimes mistaken for the poison ivy, but it is easily distinguished by having five, instead of three, leaflets, all of which spread out from a common point, like the fingers of the hand.

Perhaps no plant is more popularly recognized as harmful than the poison ivy. Its effects upon the human skin are familiar to everyone, and as its victims far outnumber those of all other species combined it has come to be regarded as the principal poisonous plant of America. Some of its other common names are poison oak, poison vine, and mercury. Its nearest relative is a plant known to botanists as *Rhus diversiloba* (fig. 25), which grows in similar situations at low altitudes

throughout the Pacific Coast from Lower California to Canada and northward. Western people call it poison oak because the leaves, though very unlike those of the common Eastern oaks, bear a considerable resemblance to the common species of the West. The leaves differ in size, as well as in shape, from those of the poison ivy. Ranked together in the same genus are two other poisonous plants, which, although they produce the same effect upon the skin, are yet totally different in their gross appearance, being thus more closely allied to the sumac or nonpoisonous species of the group. Only one of these is at all common, and that is the poison sumac (*Rhus vernix*), which is found growing in swamps from Florida to Canada and westward to the Mississippi Valley. It is a shrub or small tree, 6 to 18 feet in height, with long pinnate leaves having from 7 to 13 smoothly polished leaflets. It is also commonly known as "poison dogwood," "poison ash," and "poison elder." (Fig. 26.) The other poisonous sumac (*Rhus michauxii*) is a rare shrub, recently rediscovered in North Carolina.

FIG. 25.—Poison oak (*Rhus diversiloba*).

Poison ivy has long been regarded by the ignorant with a degree of awe akin to superstition. No one was able to tell how it produced its effects, and why it attacked some people and not others. Mysterious principles were relied upon to explain the phenomena, and up to the present time the common belief has been that the poisonous constituent was really an exhalation from the plant. In the latter part of the last century it was so regarded by the expert; then, as our knowledge of plant chemistry advanced step by step, it was attributed more concretely to a specific gas, a volatile alkaloid, and a volatile acid like formic acid. More recently still, bacteria have been accused of causing the affection. Experiments have seemed to verify these ideas in turn, but the falsity of all has at last been proved by the discovery of a more tangible compound. In January, 1895, Dr. Franz Pfaff, of Harvard University, announced that the poison is in reality a nonvolatile oil. Numerous experiments have been performed with the purified oil, and it has been shown to produce exactly the same effects as the plant itself. Dr. Pfaff has called this substance "toxicodendrol." It is found in all parts of the plant, even in the

wood after long drying. Like all oils, it is insoluble in water, and therefore can not be washed from the skin with water alone. Alcohol dissolves it readily. Alkalies saponify it, and thus render it inert, but this result is more easily obtained by an alcoholic solution of the sugar of lead (lead acetate). Numerous experiments show that when the smallest amount of this oil is applied to the skin it is very gradually absorbed in the course of a few days, and that within certain limits the longer it remains upon the skin the greater will be the effect produced.

In an experiment performed by the writer at the Department of Agriculture the oil was applied to four spots on the wrist and carefully kept from spreading to other parts of the body. At the end of an hour one of these spots was well washed with successive treatments of pure alcohol; in three hours another was washed clean in the same manner; the other two were allowed to remain three hours longer. The effect produced on the first spot was very slight; that on the second was more marked, but did not equal the effect produced on the other two, which was about equal. The affected places were all within an inch of each other, but all remained wholly distinct, a circumstance which very clearly shows that the affection is not spread through the agency of the blood. Subsequent applications of an alcoholic solution of the sugar of lead gave immediate and permanent relief. In practice it is not desirable to use strong alcohol, which is apt to be too irritating to a sensitive surface, but a weaker grade of from 50 to 75 per cent should be preferred, and to this the powdered sugar of lead is to be added until no more will dissolve. The milky fluid should then be well rubbed into the affected skin, and the operation repeated several times during the course of a few days. The itching is at once relieved and the further progress of the malady is checked. The remedy has been tried in a large number of cases and has always proved successful, but it must be remembered that it is itself a poison when taken into the mouth.

FIG. 26.—Poison sumac (*Rhus vernix*).

Poison ivy being so great a public nuisance, it is strange that no legal measures have ever been carried out to suppress its growth. Municipalities protect their people against diseased food by the appointment of inspection agents, and farming communities defend

themselves against the ravages of animals by bounties. Why should not this plant in some way be provided against, especially now that its poisonous nature and its antidote are so exactly known? Much would be accomplished if the owners of suburban places of popular resort were compelled to weed out the vine from their premises. The regulation might also be made to cover its destruction along the country roadsides.

THE AMERICAN WATER HEMLOCK.

The American species of water hemlock (*Cicuta maculata*) is by far the most virulent plant native in the United States. (Fig. 27.) It is found growing at low elevations, along streams and ponds, and in marshy ground throughout the eastern portion of the continent, not extending apparently very far west of the Great Lakes. It is perennial in duration and grows to a height of from 4 to 8 feet. In some river marshes it is so extremely abundant that in early summer the landscape is whitened by its bloom. It belongs to the well-known parsley family, and may easily be distinguished by its fascicled, spindled-shaped roots, which are from 1½ to 3 inches in length, and by the trellised structure of the underground portion of its main stem. Both of these parts are strongly impregnated with a yellow, aromatic, oily fluid, which has an odor resembling that of the parsnip. A few of the common names by which the plant is known in various localities are, water hemlock, wild hemlock, beaver poison, musquash root, muskrat weed, cowbane, and children's bane. It is frequently mentioned in the newspapers under the erroneous name of "wild parsnip." The plant is closely allied to the less common and somewhat less virulent poison hemlock (*Conium maculatum*) with which Socrates was put to death, but it has several nearer relatives equally poisonous with itself. *Cicuta virosa*, the species which is particularly dreaded in Europe, probably does not occur in the United States; *C. bulbifera* is found from Indiana to Delaware; *C. vagans* in Washington, Oregon, and northern California, and *C. bolanderi* in California. All grow best in damp, marshy places, and closely resemble one another in external appearance and toxic properties.

The victims of these plants are chiefly but not exclusively herbivorous animals. The underground portions are the most poisonous, and as these are often washed, frozen, or dug out of the soil during winter and early spring, they are sometimes eaten by children and by animals, the former mistaking the roots of the American water hemlock for horse-radish, parsnips, artichokes, sweet cicely, or other edible roots, the animals eating the various kinds because they are among the first green substances to appear in the spring. In marshes where any of the species is abundant, cattle are also said to be poisoned by drinking the water which has stood in contact with roots that have been crushed by being trampled upon. The poisonous constituent

resides in the aromatic oily fluid already mentioned. This fluid has not been thoroughly analyzed in the case of the American water hemlock, but it is highly probable that besides conine all the species contain cicutoxine, a resinous substance which is characteristic of the water hemlock of Europe and is much more poisonous than the alkaloid conine. Cicutoxine was discovered in 1875, and has since been shown by animal experimentation to produce the same symptoms as the plant itself.

No estimate can be made of the amount of damage done to live stock by these various species, but it is not insignificant. The human victims of the American water hemlock probably average a considerable number per annum. In the State of New Jersey alone two quadruple cases of poisoning were reported during the spring of 1896, which resulted in the death of two individuals. Falck, a German authority, reports a 45 per cent fatality in thirty-one cases of water-hemlock poisoning occurring in Europe.

FIG. 27. American water hemlock (*Cicuta maculata*).

The symptoms of poisoning are vomiting, colicky pains, staggering, unconsciousness, gnashing of the teeth, and frightful epileptiform fits, ending in death. As no chemical antidote is known, the treatment must consist in a thorough cleansing of the alimentary canal and in combating the symptoms as they arise by the use of chloroform, chloral, and such agents as seem to be indicated at the time. Herbivorous animals which have swallowed a sufficient dose generally die, but they are sometimes saved by two or three doses of melted lard, which tends to retard the absorption of the poison in the stomach, and also facilitates its expulsion through the intestines.

One case will show the general nature of the symptoms. At Boundbrook, N. J., in March, 1896, two boys and two girls, while returning from school for lunch, stopped to look at some workmen digging a ditch. One of the girls spied some water-hemlock roots which had been thrown out of the ditch and which she took to be horse-radish. More were soon found by the others and, as they proved somewhat agreeable to the taste, all ate of them to a greater or less extent. After arriving home, but before finishing luncheon, one of the girls

was taken violently ill with dizziness and nausea, and was soon in convulsions. A physician was summoned immediately, but the girl died shortly after his arrival. The others were affected in the same way but not so violently, and they were finally saved by skillful treatment. The species was determined from specimens sent to the Department of Agriculture and from plants grown from these roots.

THE DEATH CUP.

The death cup (*Amanita phalloides*) is the most poisonous of all the fleshy fungi. (Fig. 28.) It is found in summer and autumn throughout the greater part of the United States, growing upon the ground in the woods at medium and lower elevations. The stem is white. When young it is solid, but afterwards it becomes somewhat hollow and pithy. The base is surrounded by a characteristic cup-shaped appendage, the remnant of a veil which covers the entire plant when young. The length varies from 3 to 5 inches. The cap is viscid when moist, and is generally smooth and satiny, but it may sometimes bear fragments of the outer covering, or veil. The gills and spores are white. Several varieties of the plant exist, the one most common having a white or yellowish cap; but this may be green or even spotted when growing in deep shade. The general shape is much like that of the common mushroom. It is also like that of the fly Amanita (*Amanita muscaria*), which is, perhaps, more common, but is less poisonous. From the former it is at once distinguished by its basal cup-shaped appendage, and a child can usually distinguish the fly Amanita by its more brilliant coloring.

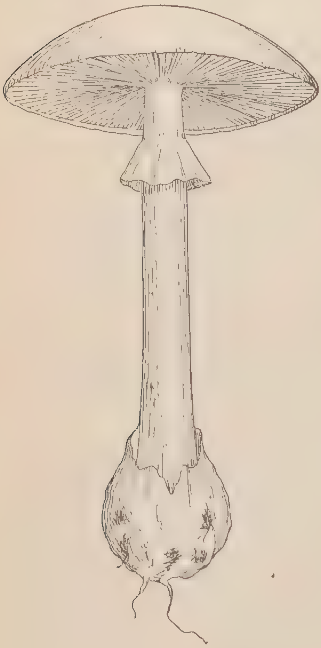

FIG. 28.—Death cup (*Amanita phalloides*).

The death cup occurs in Europe as well as in America, and it is mainly from European sources that our knowledge of it is obtained. Pliny ascribes numerous cases of poisoning to fungi, and it appears probable from the descriptions given that the poisoning was produced in most instances by the above plant or its several varieties. One foreign authority has collected 51 cases of poisoning caused by the death cup, 75 per cent of which were fatal; and another has found descriptions of 48 cases which occurred in Germany alone in the years from 1880 to 1890. In the United States it is said that as many as 25 deaths during the summer of 1893 were due to some species of Amanita.

The amount of the substance of this fungus which is necessary to

produce death is very small. The third part of a medium-sized uncooked cap is said to have proved fatal to a boy 12 years of age, and smaller amounts have affected older persons very seriously. Even the handling of specimens and the breathing of the spores have apparently given rise to very pronounced uneasiness. The spores are also suspected of having caused trouble by being deposited on edible fungi which were placed in the same basket.

The fresh fungus is very inviting in appearance and has no bad taste when eaten either raw or cooked. There is no uneasiness felt by the victim until from nine to fourteen hours after eating. Severe abdominal pain then sets in, which is rapidly followed by nausea, vomiting, and extreme diarrhea, the alvine discharges assuming the peculiar rice-water condition which is characteristic of Asiatic cholera. These symptoms are persistently maintained, but without loss of consciousness, until death ensues, as it does in from two to four days.

Since the year 1869 death from Amanita poisoning has generally been attributed to the alkaloid muscarine (wrongly called amanitine). This is true of a large number of cases. In some, however, it has been noticed that the toxic action was quite different, and that the effects could not be successfully counteracted by the use of atropine, which is a perfect antidote to muscarine and certain more or less closely related compounds. This difference seemed to be especially marked in the case of the death cup, but chemists were unable to isolate and describe its peculiar principle until recently. This was done in 1891 by Kobert at Dorpat, in Russia, and the substance was called phallin. Its characteristic action consists, not in inhibiting the action of the heart, but in dissolving the red blood corpuscles and permitting the blood serum to escape through the alimentary canal.

Phallin is a remarkable substance. Nothing like it was known to exist in plants until 1884, when abrin, the poison of the East Indian jequirity (*Abrus precatorius*), was isolated and described by two Englishmen. Mitchell, an American, had shown in 1860 that a similar substance existed in the venom of the common rattlesnake, and others have more recently shown that such compounds are not uncommon in nature. They are now known to exist in the venom of various serpents, in the poison gland of some insects, in the cultures of such pathogenic bacteria as those characteristic of diphtheria and typhoid fever, and in a few plants, such as the barbadoes nut and the castor-oil bean. All partake of the nature of albumen, and are therefore called tox-albumins. They are easily coagulated and thus rendered inert by a temperature somewhat below that of boiling water, and all dissolve readily in a solution of common salt. Phallin is odorless and tasteless, and, like the other tox-albumins, causes death only after a long interval. The fatal dose for cats and dogs is less than one-tenth of a milligram per kilogram (seven ten-thousandths of a grain per pound) of body weight, and death follows in from four to seventy-two hours.

Salt water is commonly used in the preparation of fungi for food, and some pretense at cooking is generally observed; such treatment, although it would not remove the poison of the deadly Amanita (*Amanita muscaria*), would, if thorough, totally remove that of the death-cup fungus. The uncertainty of an adequate treatment is so great, however, that the plant should be rejected as a food and branded as poisonous. The danger is made much more emphatic by the fact that there is no known antidote for phallin. When a case of poisoning occurs, the action of the muscarine-like compounds, which are in all cases to be suspected, is to be counteracted by the hypodermic use of atropine, but the ultimate effects of phallin are only to be offset by transfusions of common salt, or by blood taken fresh from the veins of some living animal. There is generally little need of agents to evacuate the stomach and bowels.

The following account of a case of poisoning by the deadly Amanita was reported in one of the Washington (D. C.) newspapers for October 18, 1894. The report was verified and enlarged by consultation with the physicians who attended the patient. The victim, Chung Yu Ting, was a highly educated Chinaman, who was serving as interpreter in the household of a Russian nobleman. The fungus was identified by the microscopist of the United States Department of Agriculture.

Having been accustomed to eating fungi in China, Chung gathered a large quantity of this luscious-looking fungus and ate it at 2 p. m. on Saturday, after preparing it according to his own method. At 9 p. m. no ill effects had been observed, but shortly after midnight he was found in terrible agony. The vomiting and purging had been profuse, and in the bowl containing the vomit, the tough, apparently undigested morsels of fungus were found in great numbers. Medical aid was summoned at once and hypodermic injections of atropine and morphine given, but apparently without effect. The discharge of blood and blood serum which began in the early course of the attack continued to be so profuse that it was soon found impossible to raise a blister on the abdomen by the use of cantharides. Nothing whatever could be retained on the stomach, and it was found impossible to give nourishment in any way. Hypodermic injections of nitroglycerine and strychnine were used with good effect upon the heart, but the continued use of atropine appeared to do no good. The rice-water discharges continued unchecked, and the patient's strength declined steadily until death occurred on the morning of the fourth day after the fungus was eaten.

TIMOTHY IN THE PRAIRIE REGION.

By Thomas A. Williams,
Assistant, Division of Agrostology, U. S. Department of Agriculture.

GENERAL REMARKS.

Scarcely more than a decade ago nine out of every ten farmers on the Western prairies would have said to you, "You can't grow timothy in this country." True, a few of the more careful men in the more favored localities seemed to have no difficulty in making a success of timothy growing, but the average farmer of the prairies found so much trouble in growing it that he was firmly convinced of the uselessness of making the attempt. This was especially true if his farm was on the uplands.

However, there was little need of any other forage than the native grasses in the earlier days. Land was plentiful, and every farmer was within easy reach of enough vacant territory to supply his stock with the necessary hay and pasturage. Consequently most of the attempts at growing timothy were of such a half-hearted nature that there is little wonder that so few were successful. Then, again, few farmers understood the nature of the soil, or, for that matter, of the timothy itself, sufficiently to go about the work intelligently. Soil and climatic conditions were very different from those in the East, where most of them had gained their experience in timothy growing. Though there was usually plenty of rain in early spring and in autumn, there was very little during the summer. Such conditions were favorable to the growing of small grain, but the hot, dry summers were fatal to timothy without a different treatment from that usually given to it. Moreover, as is always the case in a newly settled region, the tendency at first was to loose and careless methods of farming. Too often the only attention the farmer gave to the timothy field after seeding it was to take off whatever crop of seed or hay there might be and then to allow the stock to run at will over the field during the remainder of the year. As the land was usually very smooth and it was possible to run the mower very low, the field would often be literally shaved close to the ground. Of course, such treatment resulted in a very short-lived meadow, which "would not pay," and timothy growing was abandoned, at least for the time. This has been the custom and these the results of thousands of attempts to grow timothy on the prairies of Kansas, Nebraska, the Dakotas, and Minnesota.

But as the country became more thickly settled, native hay and pasture lands grew scarce and correspondingly less adequate to supply

forage for the stock. Then it was that timothy growing was begun in earnest. By this time farmers had come to a better understanding of the methods of handling the soil as well as of the needs of the timothy. Then, too, the breaking up of the sod and the setting out of groves had produced a change in atmospheric conditions more favorable to the development of the grass. Hence, in spite of the early prophecies regarding it, timothy is to-day one of the most commonly cultivated forage plants throughout a large portion of the great prairie region of the Mississippi and Missouri valleys. Good timothy meadows may be found not only along the lowlands of the valleys, but also on the farms of the upland prairies. There are upland meadows in eastern Nebraska which have been in constant use for fifteen years or more, and in that time have not failed to yield a paying crop. Wherever irrigation is possible, excellent crops of timothy are easily grown.

SEEDING.

The methods of seeding down to timothy in practice among farmers and stock raisers vary widely according to the peculiarities of the different regions. Experience has long since shown that what will succeed in one may fail in another. There are, however, certain features of timothy growing to which everyone must give close attention if he would secure the best results.

Timothy is a surface feeder, and hence the soil should be prepared in such a way as to concentrate an abundance of plant food near the surface and to allow the roots to penetrate to as great a depth as possible. One of the most common practices is to begin at least a year before seeding to the grass and put the field into some crop which will allow the land to be given a deep, late plowing, and a heavy coating of manure. If the land has been kept clean, it will usually be in good condition for fall sowing, if the season is favorable. If not, it may be further enriched, fall plowed if necessary, and seeded the next spring. It has been found that while the soil should be mellow down to a good depth, yet it should not be too loose, or it dries out too readily, and the timothy will not form a good sod. This has led some farmers to the belief that pasturing is a good thing for timothy meadows. They would often find that the grass in a growing meadow would stool out better after the stock, especially cattle or horses, was allowed to run on it for a time. The trampling of the stock simply compacted the soil which before had been too loose. Very often the farmer would be misled by this and would allow his stock to run on the meadow to such an extent as to ruin it entirely.

In Iowa and eastern Nebraska the roller is often used to compact the ground, particularly if it is cloddy, or if the seeding has been done in the spring and a nurse crop has been sown. In the lighter, sandier soils of the Dakotas and of western Nebraska rolling can not be practiced, since the soil is made so fine that the winds blow it off and uncover the seed or blow both seed and soil away.

In Nebraska and the Dakotas very fine stands of timothy are often

obtained by sowing in the fall on millet stubble. In this case the land is given a thorough coating of well-rotted stable manure, and is plowed very deep and as late as possible, so as to kill all the weeds that may start. The millet is cut early and the timothy is sown directly on the stubble and covered by a thorough dragging with a heavy harrow. In this treatment the land should always be made very rich and the millet should be cut before the seed has developed. It is also a good plan to leave the stubble long, to serve as a snow catch for the protection of the timothy. A more common practice is to manure the ground thoroughly, plow, and plant to corn or some other cultivated crop that does not draw heavily upon the soil; manure lightly with well-rotted stable manure the next spring and sow to timothy, using wheat or some other small grain as a nurse plant. The wheat is usually sown broadcast and covered with a cultivator, harrowed smooth and the timothy sown later and the ground rolled or gone over with a brush drag. This is one of the most successful methods. Another plan often followed is to take a field that has raised a crop of small grain (say, oats), manure heavily, and fall plow, sow in spring to wheat or barley, either with drill or broadcast, and seed to timothy, either with the nurse crop or later.

Timothy is often used in reclaiming worn-out native meadows and pastures, and with proper treatment very good results are obtained. It seldom yields well in pastures, however, for more than two or three years in succession unless the land is very rich and moist. It is therefore the best plan to sow blue grass with the timothy, and by the time the latter is pastured out the former will have occupied the land. Sowing on native turf is usually done in early spring. The seed is sown broadcast, and then the ground is gone over thoroughly with a heavy harrow. Native meadows on low, rich soil, that have become thin from continuous close cutting may be very materially strengthened by the addition of a little timothy in this manner, as the writer knows from experience in both Nebraska and South Dakota.

In some parts of the Dakotas timothy is often drilled along with wheat simply for the fall and spring pasturage, and then the field is plowed and planted to corn. This has been done with considerable profit on large stock farms when seed is not too dear and there is plenty of moisture. The regular pasture may be allowed to rest during fall and spring, and thus be in better condition for the summer. The green timothy makes a valuable addition to the straw and other "roughness" which the stock gets in the field during the late fall and early spring.

The amount of seed used per acre varies from 8 to 16 quarts, but in common practice it is seldom more than 12 quarts. For all purposes broadcasting gives better results than drilling when timothy is sown alone, but it is necessary to cover the seed more deeply than is the custom in the East on account of the lighter soil and the liability to more or less protracted droughts.

AFTERTREATMENT OF TIMOTHY MEADOWS.

In the great majority of cases the real cause of the success or failure of the timothy field lies in the treatment it receives after it has been seeded down. As a rule, it is not a difficult matter to get a good stand of grass. The trouble is in so handling the field as to get good returns and still keep the sod in a healthy, growing condition.

Throughout the entire prairie region the time and manner of cutting have much to do with the vitality of the sod. In all dry situations timothy develops bulbous thickenings (fig. 29) of greater or less extent at the bases of the stalks, which become filled with water and enable the plants to survive droughty periods. If the cutting takes place too early in the season, these bulbs do not become sufficiently developed and the plants are more easily influenced by the hot, dry weather which often prevails during summer and autumn. Again, the conditions may be such that a late cutting may do serious damage to the sod. If the early part of the season has been dry and rains in July produce a second growth, the farmer usually waits as long as he can before cutting, in order to get as large a yield as possible. It is seldom that much aftermath is developed, on account of the lateness of the second growth, and if the timothy is cut too close to the ground the sod is very likely to suffer badly. Hence, a long stubble should be left. In fact, it is never a good plan to cut closer than 3 or 4 inches. When timothy is sown in the spring, it is usually best to go over the meadow with the mower to keep the weeds down, but not with the intention of cutting a crop of hay. Sometimes a little seed may be obtained the first season, but this is generally needed to fill in thin places in the sod.

The best hay is obtained by cutting during full bloom or when the "blossoms" fall. The feeding qualities are best at full bloom, but most farmers prefer to cut a little later, as the pollen makes the hay "dusty," which is avoided by waiting. It sometimes happens that, on account of lack of moisture, the first growth is light, and abundant rains in June or July may cause a strong second growth to spring up, which will not be in its prime until the first has reached an advanced stage of development. In such cases it would be more profitable to cut late, provided the proper precautions are observed as to the condition in which the sod should be left. There is a growing sentiment in favor of cutting timothy with the self-binder for hay as well as for seed, and the practice has much to commend it. With right treatment the hay cures well, is much more easily handled and fed, and can be stored in a more limited space than when cut in the ordinary way.

Experience has shown that, under the ordinary conditions obtaining in the West, pasturing has a bad effect upon the vitality of the timothy meadow. The trampling of the stock destroys the bulbs of the plants and packs the ground, rendering it more liable to bake.

Sheep are particularly hard on timothy, because of the close grazing and excessive trampling resulting from their habit of feeding in flocks. When the meadow is on low, rich, moist bottom land, it will stand a limited amount of grazing. There is some doubt as to whether spring or fall pasturing does the greater injury. At the Utah Experiment Station, in a two years' trial, spring grazing did the most damage. Many farmers, however, hold that spring grazing does less damage if the stock is taken off before the timothy begins to "joint." It is more than likely that much depends upon the character of the season and the condition and treatment of the sod.

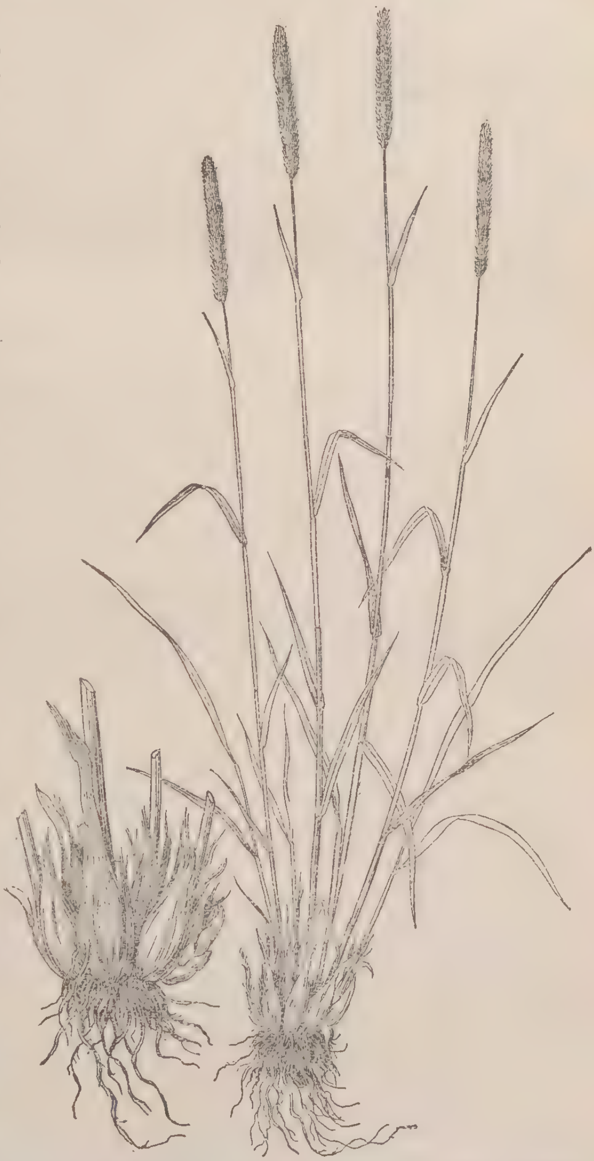

FIG. 29.—Timothy, showing the bulbous bases of the clustered stems in old plants grown in dry, hard soil.

Since most of the nourishment which this grass draws from the soil comes from near the surface, the meadow should be given a top-dressing every year or two. Ordinary stable manure is most commonly used in the West, since it is the only fertilizer easily accessible. It should be well rotted when applied, and then it will be readily available to the plants. In practice the manure is put on the field during the fall, winter, or spring, as best suits the convenience of the farmer. The least waste occurs and the best results are obtained, however, when application is made in early spring.

It is a frequent thing for the timothy meadow in the West to become "hidebound." This usually occurs in meadows that have been in use for some years, and is due mainly to two causes. In the first place, through insufficient cultivation the driving rains and hot summer suns pack and bake the ground so hard that the plants can grow only with great difficulty; in the second place, as the plants become older a great many offshoots are developed, each with its bulbous base, and all are crowded together in such a small area that none can make a satisfactory growth. The remedy for such a condition of things is to give the meadow a good top-dressing in early spring and follow this with a heavy harrow, thoroughly tearing up the sod. This breaks up the crust and allows the soil to absorb water more readily, while it tends to lessen the loss by evaporation. It also separates the bunches of timothy plants and allows them to develop properly. If the meadow is top-dressed and harrowed often enough, this "hidebound" condition will be avoided.

From the fact that there is less need of frequent rotation in the West than in the East, the Western farmer usually desires a long-lived meadow. With this end in view, he welcomes any practice that will increase the vitality of the meadow, and hence its longevity. Top-dressing, harrowing, or cutting up the sod with a cornstalk cutter, mowing at the proper season and in the proper manner all tend to increase the life of the meadow. It is also a good practice to sow a small quantity of red clover or alsike with the timothy. These not only add materially to the forage obtained, but also have a good effect upon the soil, and are thus a benefit to the timothy. It is usually necessary to sow a small quantity of clover about once in every three years.

Many farmers sow also a small quantity of redtop with their timothy. This grass fills in the spaces between the bunches of timothy, and hence a more even sod is produced. It is not a good plan to use too much redtop, however, or it will crowd out the timothy, as it is very hardy and spreads more rapidly than the latter.

GROWING TIMOTHY FOR SEED.

Western-grown seed is eagerly sought by many seedsmen on account of its greater vitality, and hence the growing of timothy for seed has become quite an industry in certain localities. The heads always fill out well, and even when quite thin on the ground the yield is sufficient to render the business a profitable one on account of the relatively low price of land and the small amount of labor and expense necessary to grow and market the crop. While the vitality of Western seed is high, it requires a great deal of care to harvest it in such a manner as to get a high grade in color. An excessively bright sun is very likely to bleach out the seed and thus injure its selling qualities. On the other hand, the ease with which timothy can usually be cured and the seed saved in the West are points in its favor.

As a rule, timothy is cut at about the time the early maturing heads are beginning to be overripe. When the seed in most of the heads is ripe enough to cut, the leaves are still quite green, and hence the straw makes fairly good feed after thrashing. The cutting is usually done with a self-binder, and the bundles are made rather small and bound somewhat loosely. They are shocked two and two, and the timothy is usually thrashed, without stacking, as soon as it is thoroughly dry. The hauling is done, if possible, in racks with tight bottoms, so that the shattered seed may be saved. In this way, though a small amount of seed is often lost because some of the heads are not well ripened, the loss is more than made good by the better quality of the straw, and the farmer gets a yield of from 6 to 12 bushels per acre of first-class seed in addition to a large amount of forage of a fair quality, which can be used to good advantage as horse feed during the winter or as "roughness" for fattening cattle or other stock.

If the timothy is allowed to stand too long, there is danger of as much loss from shattering as there is gain from the later ripening heads, and then the forage is rapidly deteriorating all the time. The shocking must be carefully done, and the bundles handled as little as possible in getting them to the thrashing machine. The timothy must not be allowed to stand too long in the shock, as again there may be considerable loss from shattering, and the quality of the seed may be injured by bleaching through exposure to sun and rains.

THE QUALITY OF WESTERN-GROWN TIMOTHY HAY.

A finer quality of hay can be grown in the West than in the East, but the average yield per acre is less, except under irrigation. The following table gives a comparison of the chemical constituents of Western hay, cut just after blooming, with the average of eleven analyses, chiefly of hay grown in the East:

Air-dry material.

Constituent.	Eastern hay (average of eleven analyses).	Western hay (South Dakota).
Water	14.2	10.4
Ash	4.4	6.6
Ether extract	3	3.2
Crude fiber	28.1	30.8
Crude protein	5.7	7.9
Nitrogen-free extract	44.6	41.1
Nutritive ratio	1:17	1:12.2

It will be seen from this that the Western hay contains more crude fiber and more crude protein and has a narrower nutritive ratio. The latter fact renders it more nearly a well-balanced ration than the average, and hence of more value to the consumer. The conditions of hot sun, dry weather, and excessive evaporation under which the Western

hay is grown readily explain the larger percentage of crude fiber, and the richness of the soil in nitrogenous elements is undoubtedly responsible for the larger percentage of protein present.

Careful attention to the methods of culture, mentioned in the preceding pages, has made timothy growing a success throughout a large portion of a vast region in which it was once maintained that it could not be grown, and there is every reason to expect that its cultivation will become still more general. There is little doubt that it will continue for many years to come to be the principal grass sown for hay, for, though it lacks some of the characteristics that a perfect forage plant should possess, it is certainly the best hay grass for average farm conditions that is at present available.

On an upland prairie farm in eastern Nebraska, which was the writer's home for many years, there is a timothy meadow which has

FIG. 30.—A timothy meadow at haying time in the Gallatin Valley, Montana.

given a profitable yield every season for over fifteen years in spite of severe droughts, and the sod is still in a good, healthy, growing condition. It has never been reseeded, and clover has been sown but once. During the past four years, two of which were very dry, the average yield has been $2\frac{3}{5}$ tons per acre, the lowest yield being $1\frac{1}{2}$ tons and the highest $4\frac{2}{10}$ tons. Similar fields are found in the Dakotas and other prairie States.

In the Dakotas, Montana, and other States where irrigation is practiced, enormous crops of timothy are raised. In the James Valley, in South Dakota, and in the Gallatin Valley (fig. 30), in Montana, the writer has seen crops of timothy and of timothy and clover raised under irrigation that were very fine indeed, considerably exceeding in value the crops of wheat raised under like conditions.

THE COUNTRY SLAUGHTERHOUSE AS A FACTOR IN THE SPREAD OF DISEASE.

By CH. WARDELL STILES, Ph. D.,
Zoologist of the Bureau of Animal Industry.

INTRODUCTION.

Generally speaking, the places for slaughtering animals for food may be divided into large *abattoirs* and local *slaughterhouses*. The former are usually located in cities, and operated in connection with packing houses. The latter are used chiefly by the meat dealers of the country towns, and the animals slaughtered at these places are generally, if not always, for local consumption. In this article it is intended to discuss only the local slaughterhouses in their relation to disease, and the criticisms here made do not apply to the large abattoirs which prepare meat for export and interstate trade in accordance with the system of Government inspection now in force.

It is impossible to ascertain from the State authorities the total number of places of slaughtering in either of the States discussed, so that no definite figures can be given covering the entire area visited, but a certain number of representative towns will be considered, in which the data were obtained by personal investigation.

The butchers of the counties visited supply themselves with meat from the following sources:

(1) Some meat dealers, especially those of the cities and larger towns, obtain all their meats from the large packing houses and do no slaughtering themselves; this class does not, therefore, enter into the field of this article.

(2) In a few cases meat men were found who did their own killing, but who had no regular place for slaughter. These men would drive from farm to farm and buy one or two animals, which they killed at the place of purchase, throwing the offal of the slaughtered animals to the farmers' hogs. They would take the dressed or partly dressed carcass to their meat shop and place it on the block.

(3) In a number of cases small dealers were found who had no slaughterhouse of their own, but who did all their killing at slaughterhouses controlled by other local butchers.

(4) In two towns at least it was learned that farmers occasionally slaughtered their own animals and brought them to town dressed or partly dressed, selling them in halves or quarters to the local butchers or to families, hotels, restaurants, etc. The farmers were in the habit of feeding the offal of the slaughtered animals to their hogs.

(5) The majority of the local dealers in small towns own or rent small slaughterhouses. In nearly all cases these houses are located on or just beyond the town limits. They are frame structures, generally of one room, built directly on the ground or raised several feet, and surrounded by a small yard, or in many cases situated in a large field.

In perhaps the majority of cases the butchers controlled a small piece of land, and, as a rule, hogs were kept on the premises to eat the offal. In many instances the houses were located on the banks of rivers or creeks into which the premises drained. Frequently the offal was thrown down an embankment toward the water and left there to be eaten by hogs and rats or to decay and drain into the stream. In some cases the slaughterhouses were located on farms. These farms were either owned by the butchers or a farmer would give to the butcher, for his slaughterhouse, the use of a piece of ground on the corner of his premises in return for the use of the offal as food for his hogs.

A very important matter from the standpoint of public hygiene is that in case a town was provided with more than one slaughterhouse, the houses were rarely segregated, but were scattered north, south, east, and west, each butcher apparently trying to place his house in such a position as to prevent any undue amount of curiosity on the part of his competitors as to the character of his stock.

NOTES TAKEN AT THE VARIOUS SLAUGHTERHOUSES.

After this general introduction, it may be well to give some notes taken upon the premises of various slaughterhouses. The plan of inspection followed was first to call on the local board of health and the mayor of the town, in order to obtain as much information as possible regarding the location of the houses, character of the butchers, etc. A visit was then made to the dealer, and permission to visit his slaughterhouse was requested; at the same time information was requested concerning the number of animals used, the origin and disposition of the stock, etc. In these notes any statements not made from personal observation are given upon the authority of the mayor, the local board of health, or the butchers themselves. As a rule, permission to visit the grounds was easily obtained and all questions were cheerfully answered. In some isolated cases, however, permission to enter the premises was refused by the butcher, and these places were then inspected only from a distance. It is needless to state that these premises were found in poor condition.

The cases cited below are taken at random from notes covering nineteen towns in one State and ten towns in another. The number of inhabitants of the towns is for the year 1890.

Town 1.

Inhabitants, 1,276. Number of slaughterhouses, 2. Proportion of slaughterhouses to inhabitants, 1 to 638.

Slaughterhouse 1.—About a mile west of corporation limits. Frequent complaints have been made by persons residing in the vicinity, but at present the premises are said to be in much better condition than formerly. About 40 hogs are on the grounds, feeding on offal and corn; these hogs are used only for local consumption. The offal is thrown out of the slaughtering room down a hill, and remains there until eaten by hogs and rats or until decayed; the premises drain into a creek, and are overrun with rats. Of 14 rats examined, 10 were infected with trichinæ.

Slaughterhouse 2.—About a mile and a half east of town; few hogs present, feeding on offal and very poorly kept; these hogs are used only for local trade. Premises badly infested with rats; 3 out of 8 examined were trichinous.

Town 2.

Inhabitants, 2,448. Slaughterhouses, 3. Proportion of slaughterhouses to inhabitants, 1 to 816.

The health officer of this town, when asked about trichinosis in this region, advised me to "ask some horse doctor about it, as that disease belonged to horse doctors rather than to physicians." He considered an inspection of meats useless, "as no disease could be communicated through the food supply." As long as such a man is allowed to hold the important position of health officer there need be no surprise if disease is widespread.

Slaughterhouse 1.—Butcher owns slaughterhouse a mile and a half southeast of town, the yards covering about 40 acres; premises in fairly good condition. His shop in town is full of rats; 4 out of 7 examined were trichinous. Butcher stated he had repeatedly attempted to feed hogs on offal, but found that they did poorly; one of the hired men stated that the proprietor had recently shipped 2 car loads of hogs from his slaughterhouse to abattoirs.

Slaughterhouse 2.—Butcher slaughters on his own farm, 2½ miles north of town; keeps about 30 hogs, but does not feed for shipment; shop and slaughterhouse are both dirty and poorly kept; his 22 cats, however, seem to keep the rats down.

Slaughterhouse 3.—As filthy, dirty, and rickety a place as can well be imagined; situated about a mile east of town; premises are absolutely honeycombed with rats; of 5 rats examined, 3 were found infected with trichinæ. How the board of health can allow such a nest to exist passes comprehension, and how people can purchase meat prepared in such a place is a question the writer will not attempt to answer.

Town 3.

Inhabitants, 1,088. Slaughterhouses, 3. Proportion of slaughterhouses to inhabitants, 1 to 363.

Slaughterhouse 1.—Half a mile east of town; owner feeds about 150 hogs per year on the offal and sells them to shippers, buying hogs from farmers for his own block. The house is overrun with rats, but is in fairly good condition.

Slaughterhouse 2.—Abandoned about a year prior to visit.

Slaughterhouse 3.—Fairly good condition; 40 or more hogs per year fed on offal.

Mr. D., a hog "shipper," ships about 6,000 head per year. Of this number about 125, or $2\frac{1}{12}$ per cent, are offal-fed hogs, from slaughterhouse No. 1.

Mr. M., "shipper," shipped 3,900 hogs from December 1, 1892, to April 1, 1893. Of these hogs, 40 head, or $1\frac{1}{39}$ per cent, were offal fed, from slaughterhouse No. 3.

Town 4.

Inhabitants, 6,747. Slaughterhouses, 4. Proportion of slaughterhouses to inhabitants, 1 to 1,687.

Slaughterhouse 1.—A mile and a-half southwest of town, on the banks of a river; the filthiest slaughterhouse found during the entire tour of inspection. A look at the dirty, ignorant man in charge is enough to turn one against any meats which may have passed through his hands. He resented the visit in a most ugly manner,

although the health officer was in the party. From either the proprietor or his hired man it was very difficult to obtain information regarding the origin or disposition of their hogs. Premises in a most horrible condition and totally unfit for use as a place in which to prepare food. The killing room is small and dirty, although an attempt seemed to have been made to wash the center of the floor after slaughtering the last time. Around the sides of the room stood barrels, many of them falling to pieces, filled with scraps of meat, and of easy access to rats. The blood and offal troughs drain directly into the river. Adjoining the killing room is a dirty, filthy rendering room. Some of the swine offal is rendered and the rest of it is fed to hogs. The entire premises are overrun with rats, and the hired man remarked that he "frequently poured hot water into the rat holes and killed the rats by hundreds" as they ran out. When asked what he did with the rats, he replied that he "did nothing with them; some were eaten by the hogs, the others were left to decay." No rats examined for trichinosis, as that would have been a waste of time. Under the conditions existing at this place the infection can certainly not be less than 70 to 80 per cent. Adjoining the buildings is a yard in which hogs, chickens, and turkeys are raised. There were about 70 swine, varying from pigs three days old to large hogs.

The public certainly can not expect that the premises of a country slaughterhouse will be as clean as a reception room, but butchers, on the other hand, should not expect that the public will tolerate such filthy, disease-breeding places as the one just described.

The local health officer has no authority over this house, as it is outside the corporation limits; the State board entirely ignores the condition of the slaughterhouses, and as a result the public has no protection from the impositions practiced by such filthy establishments.

Slaughterhouse 2.—Situated about half a mile south of town; far above the average country slaughterhouse. The premises are dry, except for a small pool, which should be taken care of. There are about 20 head of cattle on the place, and the proprietor generally keeps from 2 to 50 hogs in the yards, all of which are used for local trade; these hogs have access to the offal of the sheep and steers, but the offal of the hogs is carried away in barrels and thrown into the river. An excellent feature of this place is the bone platform, which, like the house itself, is raised about 3 feet above the ground.

Slaughterhouses 3 and 4.—Two small slaughterhouses are located within a few yards of each other, about a mile and a half southeast of town. The buildings are raised above the ground and are in fairly good condition; the yards are very small and there is evidently no attempt to raise hogs; the offal is thrown into the yards and allowed to decay.

The four towns cited are fair examples of the places visited. To publish the notes on the other towns would be simply to repeat the foregoing statements. Some places were found in good condition; some in a condition that was a disgrace both to their proprietors and to the communities that tolerated their existence.

SLAUGHTERHOUSES NATURALLY CENTERS OF DISEASE.

The first matter to notice in connection with this subject is that every slaughterhouse is from the very nature of things a center of disease, and naturally the poorer the condition of the premises the more dangerous they are. These facts will appear clear if one considers what takes place at one of these houses. Even if only a few animals are slaughtered each week, the total number may amount to several hundred during the year. Some of the animals are surely diseased.

At least one of the hogs has trichinosis, and when the offal of this trichinous hog is fed to hogs which are raised upon the grounds the latter can not escape infection with trichinæ. But that is not all. The slaughterhouses are often overrun with rats; the rats feed on the offal, and when feeding on the offal of a trichinous hog they likewise can not escape infection with trichinæ. As a matter of fact, the rats captured at slaughterhouses, meat shops, and rendering establishments were found to be infected in a much greater proportion than rats taken from other sources, as is shown by the following table:

Summary of trichinosis in rats.

Rats.	Number examined.	Number infected.	Number uninfected.	Percentage infected.
Group 1:				
From slaughterhouses	63	35	28	55.55
From meat shops	7	4	3	57.14
From packing houses	2		2	
Total	72	39	33	54.17
Group 2:				
From corncribs	11	1	10	9.09
From barns	61		61	
From feed stores	1		1	
From hotel	1		1	
From unknown source	1	1		100.00
Total	75	2	73	2.66
Grand total	147	41	106	27.89

Rats act as direct transmitters of trichinosis to hogs. According to the above statistics, if a hog kept at a slaughterhouse eats a rat, the chances are fifty-five in a hundred that it will become infected with the disease. Now, suppose that a slaughterhouse is burned or abandoned, as was frequently found to be the case; the rats inhabiting the premises naturally wander to the neighboring farms or to the corncribs in order to obtain food, and of every hundred rats which leave the slaughterhouse grounds fifty-five carry with them the disease known as trichinosis. This disease they transmit to hogs, if eaten by them.

It is frequently denied that hogs will eat rats, but such denial is erroneous. Sometimes hogs have refused rats when offered to them; but that hogs do and will eat rats has been proved by experiment.

In the segregation of slaughterhouses care should be taken to destroy the rats in all the houses which are deserted, in order to prevent their wandering to neighboring farms.

From this it will be seen that every slaughterhouse where hogs are killed forms a center for the spread of trichinosis to neighboring farms, and when the offal is fed to other hogs it can not be expected that the latter will escape trichinosis any more than the rats. Offal-fed hogs are, therefore, liable to be infected to an extent varying from 10 to 100 per cent, and this custom of feeding hogs at country slaughterhouses unquestionably is mainly responsible for the spread of trichinosis among the hogs of the two States visited. When we recall that,

as was ascertained by inquiry, from one-fourth of 1 per cent to nearly 4 per cent of all the hogs shipped from certain localities are offal fed, we need not be at all surprised to find that 1 to 2 per cent of all the hogs examined at the large abattoirs are trichinous. Furthermore, since so much offal-fed pork is placed upon the local market in country towns, we need not be at all surprised should we find that a quarter or a half of all the pork sold by many country butchers is infected with trichinæ.

But trichinosis is not the only disease which the country slaughterhouse spreads by offal feeding. It is well known that tuberculosis occurs in cattle and hogs. Now, if one or two hundred of these animals are killed at a country slaughterhouse during the year, it may safely be assumed that one or more of them are tuberculous. Feeding the offal of these tuberculous animals to hogs will transmit the disease to those hogs, and these animals when used as food may in turn transmit tuberculosis to human beings.

The country slaughterhouse is also the center of infection for a number of animal parasites which are injurious to live stock or, in some cases, even to man, and which are spread by means of dogs. Anyone who has visited one of these places will have noticed that dogs soon discover the premises as a good place to obtain food. While eating the discarded organs, they infect themselves with several kinds of parasites, of which the following are the more important:

The *Echinococcus hydatid* is found in the liver, lungs, and other organs of cattle, sheep, hogs, and certain other animals. It varies in size from a small object as large as a hazelnut or smaller to a bladder the size of a child's head. This bladder contains numerous tapeworm heads, and when eaten by a dog each head produces a small tapeworm. The eggs of this tapeworm are in turn transmitted to the various domesticated animals and man, and give rise to hydatids.

This parasite seems to be on the increase in this country. The disease it causes can occasionally be cured, but in man it is said to be fatal in five years in about 50 per cent of the cases. It can, however, be almost completely eradicated if slaughterhouses are properly cared for.

The Thin-necked bladder worm is found in the body cavity, in the omentum, etc., of cattle, sheep, and hogs, and is quite common in some localities. It develops into the Marginate tapeworm when eaten by dogs. The eggs of the marginate tapeworm are then scattered by dogs on farms, in the road, etc., and infect cattle, sheep, and hogs with the bladder worm. It occasionally causes the death of young animals, as the bladder worm can not be reached with medicines.

The Gid bladder worm is found in the brain of sheep, and occasionally in other animals, but fortunately it is exceedingly rare, if present at all, in this country. When eaten by dogs, it develops into a tapeworm which produces numerous eggs. The dogs scatter these eggs on farms, sheep become infected with them, and contract the disease of "gid" or "turnsick."

The Tongue worm is found encysted in the viscera of cattle, sheep, and other animals. It is about a quarter of an inch long, and when eaten by dogs grows to be 2 to 5 inches long, inhabits the nasal cavities, and produces numerous eggs, which are transmissible to man as well as to the domesticated animals.

It is needless to enumerate all the diseases which might center at a slaughterhouse, but two more maladies, i. e., hog cholera and swine plague, demand attention. It has already been noticed that many slaughterhouses drain directly into brooks and creeks. If hogs suffering from hog cholera or swine plague are killed and the entrails thrown into a yard draining into a creek, it inevitably follows that the creek becomes contaminated and the disease then spreads to farms lower down the creek, and an outbreak of the disease will follow. The same remarks apply to wire-worm disease in sheep.

From the foregoing details and discussion, the writer is forced to adopt the view that every slaughterhouse is a center from which disease may spread, and that the chief factors concerned in the spread of these diseases are (1) offal feeding, (2) drainage, (3) rats, and (4) dogs.

PREVENTIVE METHODS.

There are two methods of meeting and lessening the dangers with which slaughterhouses threaten the farmer:

(1) Since every slaughterhouse is a separate center of disease, it follows that a reduction in number or a segregation of slaughterhouses will reduce the number of places from which disease will spread.

(2) Since offal feeding, drainage, rats, and dogs are the important factors concerned in spreading the diseases, it follows that we can control the spread of these diseases by controlling these factors.

THE SEGREGATION OF SLAUGHTERHOUSES.

An exact ratio of the number of inhabitants to each slaughterhouse can not be deduced, as the neighboring farmers naturally draw some of their supplies from the local markets. Taking, however, the number of inhabitants in towns and the number of slaughterhouses, localities can be found where the proportion varies between one slaughterhouse to 72 inhabitants and one slaughterhouse to 1,600 inhabitants. In twenty-nine towns of the two States visited sixty-nine local slaughterhouses were found. Sixteen of the towns had two slaughterhouses each, eight had three each, two had four each, and one had five.

From the above figures it will be seen that twenty-nine localities furnished sixty-nine disease centers for the surrounding country. It is also evident that if the slaughterhouses were so segregated that all the butchers of each town were obliged to do all their killing at a common slaughterhouse, we should have forty places less from which disease could spread to the farms surrounding these twenty-nine towns.

The first and most important proposition, therefore, to lessen the danger due to the country slaughterhouse is to reduce the number of places at which slaughtering is allowed, compelling all the butchers of a given town to slaughter at the same place.

This suggestion will naturally not meet with the approval of all the butchers. The objection will be made that they have money invested in slaughterhouses and that any change will mean financial loss to them. To this the reply is that all or nearly all the country slaughterhouses are frame buildings, which are not of much value; they are cheaply built, poorly arranged, etc., and represent an infinitely smaller investment than the money invested in stock by neighboring farmers; and the temporary loss to be sustained by the butcher will be infinitely less than the loss sustained in the course of time by the neighboring farmers and by the community. Further, these numerous local slaughterhouses are menaces to public health, and under these circumstances a small financial loss to a few individuals can not be taken into consideration.

Another objection that will be made by the butchers is that while the segregation of the slaughterhouses would reduce the number of centers of infection, it would not reduce the amount of infection in a given district. To this the reply is that the objection is more apparent than real, since a given amount of infection in a restricted area is more easily controlled than the same amount of infection scattered over a larger area and in different localities.

Objection will also be made that this segregation of the slaughterhouses is an innovation, an experiment, a scientific theory which is not practicable. The reply to this is, that while it is an innovation in this country, it has been tested and found satisfactory in other countries, where practical experience has borne out scientific theory and where the plan has been shown to be entirely feasible.

Objection may be raised that one butcher does not care to be subjected to having his business open to the gaze of other butchers. This objection answers itself. There undoubtedly are butchers who would object to having other butchers see the class of stock they kill or raise, and the sooner the health authorities exercise some control over these dealers the better.

In connection with the segregation of slaughterhouses it is suggested that a slaughterhouse could be built by a stock company or by the municipality and stalls let to the butchers, or the butchers could build a common house for killing, or each butcher could move or build within a restricted area to be given up to slaughterhouses.

CONTROL OF THE DISEASE-SPREADING AGENCIES.

Passing now to the most potent factors in the transmission and spread of disease from country slaughterhouses, i. e., offal feeding, drainage, rats, and dogs, let us see how these factors may best be controlled.

Disposition of offal.—The author unqualifiedly condemns the feeding of the uncooked offal of slaughtered hogs (and also of uncooked swill containing scraps of pork) to other hogs, on the general ground that this custom is a most potent factor in spreading disease, and also on the ground that butchers almost universally admit that offal-fed hogs are inferior to corn-fed hogs. It is here also specifically maintained that offal feeding at the small country slaughterhouses is the most important factor in the spread of trichinosis among our Western hogs, since the conditions found are such that undoubtedly from 25 to 100 per cent of the offal-fed hogs at these houses are infected with trichinæ. This custom unquestionably also plays an important rôle in the spread of tuberculosis among hogs. It is accordingly urged that the offal of hogs be disposed of in some other way. A dealer who kills but two or three hogs per week can not, of course, afford to render the offal, but if all the butchers of a given town or county, or of two or three neighboring towns, kill at the same place, the proportionate expense of rendering will be reduced.

There is no valid sanitary objection to feeding the offal of healthy cattle and sheep to hogs, but there are decided objections to feeding this offal in case the animals are diseased. In order to be on the safe side, therefore, it is urged that the custom of offal feeding be entirely abolished.

In large abattoirs no offal is fed, so that the claim some Europeans have made that offal feeding at Chicago and other large places spreads disease among our stock is entirely groundless.

Drainage.—If the offal is rendered, the problem of the drainage of slaughterhouses will be greatly simplified, since the greatest danger in the drainage is from the decaying offal. The latter being disposed of, the drainage system will simply have to take care of the unused blood, the water used for washing, and the rain.

Regarding the water supply, it may be stated that this is very poor in the average country slaughterhouse, but a segregation of the houses would enable the expense of a windmill or other supply power to be divided among several parties, and thus reduced, while the water supply will be increased. The drainage of the killing floors and yards is naturally quite rich, containing considerable manure, blood, etc. To drain this material directly into small creeks and rivers is somewhat dangerous for neighboring farms. As a safe method of disposal, the use of large covered cesspools situated some distance from the water supply is suggested. The cleanings from these cesspools would form excellent fertilizer, but should not be used fresh on any ground to which cattle, sheep, or hogs have access, or upon grounds planted with vegetables which are eaten uncooked. With comparatively little expense the blood could be immediately prepared as fertilizer.

The destruction of rats.—How to destroy the rats around a slaughterhouse is a serious problem. The use of "Rough on Rats" in these

places is to be condemned, as it causes the rats to wander, thus spreading disease. It is far better that diseased rats should remain on the premises than that they should wander to farms. "Rat runs" by use of ferrets or by pouring hot water into the rat holes, the presence of "ratters," and the systematic use of rat traps and rat falls will do much toward destroying these pests. Although there are slaughterhouses in the two States visited that are literally honeycombed by rats, there are others where rats are very scarce.

A most excellent "rat fall" may be made of a strong barrel, about half full of water. The cover should be placed on a pivot and well baited. Hundreds of rats may be caught with this device. It is important to dispose of the bodies of these rats so that they can not be devoured by other rats or by hogs.

Dogs.—The butcher who allows dogs access to the slaughterhouse or its grounds is directly responsible for the spread of certain animal parasites. Dogs should be absolutely excluded. The presence of cats is not attended with the same danger as that of dogs, but it is difficult to maintain cats at slaughterhouses for any length of time without feeding them on milk or other food besides meat.

GENERAL SUGGESTIONS.

The question of raising live stock on slaughterhouse premises naturally arises in connection with the question of offal feeding. The opinion upon this question needs no defense to anyone who will consider all the conditions involved. The writer is unqualifiedly opposed to the raising of any kind of stock upon premises occupied by slaughterhouses, and condemns this custom, so prevalent in some districts, as dangerous to the public health, in that it inevitably results in breeding disease in animals used for food. It is accordingly recommended that local or State regulations be made to the effect that when any stock animal, more particularly the hog, has once entered the premises of a slaughterhouse, it should not be allowed to leave those premises alive, and that it must be slaughtered within a period not exceeding two weeks.

Such a regulation would have the twofold effect of preventing the shipment of slaughterhouse hogs to abattoirs, and the limit of two weeks would prevent these animals from reaching a stage in the disease known as trichinosis where the malady is transmissible to man, in case healthy hogs became infected after entering the premises.

BUILDING MATERIAL.

Country slaughterhouses are almost invariably built of wood. The use of some other building material, such as brick or stone, is advised, as stone is more easily cleaned and holds odors less tenaciously than wood. The flooring and the pavement of the entire yard should, if possible, be of asphalt.

SANITARY POLICE.

The judging of meats involves a knowledge of disease which can not be assumed or expected to be possessed by butchers. Placing diseased meat on the block, unintentionally no less than intentionally, is dangerous to the health of the consumers. For the protection of both the butcher and his patrons, therefore, all meat should be inspected at the slaughterhouse by someone who is trained in meat inspection. As a rule, a veterinarian is best fitted for this work. Every local board of health should have a competent veterinarian among its members, and the local meat inspection would very naturally be one of his duties. It seems best, however, that the State veterinarian should have control over the slaughterhouses, and the writer would even go so far as to advise the appointment of an assistant State veterinarian whose sole or, at least, most important duty should be a sanitary supervision of slaughterhouses.

There are several reasons for suggesting that the slaughterhouses be placed under the State board rather than under the local boards. In the first place, the majority of slaughterhouses are located a short distance beyond corporation limits, and hence beyond the control of the local boards. If, however, these slaughterhouses are licensed by the State boards, satisfactory regulations can be imposed. Furthermore, the sanitary supervision of the grounds can best be performed by someone who is entirely independent of local practice, and the veterinarian who has this matter in charge should give up his entire time to it. A small country town can not, of course, keep a man for such duty, but a competent State official could be kept busy.

THE RIGHTS AND DUTY OF THE FARMER.

As a rule, there is little complaint against slaughterhouses in case the odor arising from them is not especially offensive. When complaint is made, the butcher sometimes cleans up the premises a little and the matter is dropped. From the above discussion, however, it must be evident that the odor arising from a slaughterhouse is insignificant when compared with the sanitary side of the question. It must also be evident that little will be done to better the existing conditions unless those directly affected take some decided action in the matter. The classes most affected are the farmer and the townspeople. The farmer suffers loss in his stock; the townspeople suffer loss in health. The townspeople can protect themselves against the diseases by thoroughly cooking their meats, and their interest in the matter then ends. The farmers must protect themselves in some other way, and the most natural way is to demand a better regulation of the country slaughterhouses. Let the farmer, therefore, take the initiative, and for his own protection let him demand a State control of these premises.

SUMMARY.

To summarize this subject in a few words—

1. A well-regulated system of slaughterhouses is as necessary to the public health as is a well-regulated system of schools to the public education.

2. Every slaughterhouse is a center of disease for the surrounding country, spreading trichinosis, echinococcus disease, gid, wireworm, and other troubles caused by animal parasites, and tuberculosis, hog cholera, swine plague, and other bacterial diseases.

3. The important factors concerned in spreading these diseases are offal feeding, drainage, rats, and dogs.

4. These diseases may be greatly held in check and in some cases entirely eradicated in two ways: First, by a reduction in the number of premises on which slaughtering is allowed, on which account it is urged as all important that there be a segregation of the slaughterhouses, so that all the butchers of any given town will be compelled to do all their killing in a common inclosed and restricted area. In abandoning slaughterhouses, care should be taken to destroy the rats, in order to prevent the spread of infection. Second, by regulating the factors concerned in spreading the diseases: (*a*) Offal feeding should be abolished; (*b*) drainage should be improved; (*c*) rats should be destroyed; and, (*d*) dogs should be excluded from slaughterhouses.

5. A licensing of slaughterhouses by the State boards of health and the employment of an assistant State veterinarian, whose sole or most important duty shall be a sanitary supervision of all places where animals are slaughtered for food, are necessary.

6. The appointment on every local board of health of a competent veterinarian, whose duty it shall be to control the class of meat placed upon the block, is urged. All meats should be inspected at the time of slaughter, thus securing for the local consumer the same guaranty that the National Government provides for the foreign consumer and for interstate trade.

7. The prohibiting of the raising of any kind of stock within the premises of slaughterhouses is advised, as are also State regulations to the effect that when a stock animal (horse, of course, excepted) once enters the premises of a slaughterhouse it must never be allowed to leave those grounds alive, but must be slaughtered within two weeks' time.

8. It is advisable to use more substantial building material in the construction of slaughterhouses.

9. The country slaughterhouse is more injurious to the farmer than to other classes, as he is less able to meet the dangers involved, and on this account he is urged to take the initiative in calling for a better regulation of places of slaughter.

10. When a farmer kills stock for his own use, he should burn or bury the offal, or cook it in case he feeds it to hogs.

IRRIGATION ON THE GREAT PLAINS.

By Frederick H. Newell,
Chief Hydrographer, United States Geological Survey.

INTRODUCTION.

The success of agriculture in a distinctly arid region, like the valleys of Utah, where perennial streams flow from snow-capped peaks, is a self-evident proposition. There the climate renders irrigation absolutely essential, and widely distributed, even though small, water supplies make it practicable. No settler thinks for a moment of trying to cultivate the soil until he has provided a means of applying water.

In contrast to these conditions are those surrounding the farmer on the Great Plains, especially upon the western half. Here the climate is far from arid. In certain seasons it may be called humid. The settlers coming from the Mississippi Valley have brought with them the methods of agriculture adapted to a wet country. In some years success is attained by these methods, and wonderful crops encourage the breaking up of increased areas next year. Total loss of crops and bitter disappointment inevitably follow, however, and the unfortunate settlers, if not driven from the country, alternate between short periods of prosperity and long intervals of depression.

The soil of the Great Plains region as a whole is wonderfully rich. The irregular and scanty rainfall has not leached out the natural salts, so valuable to plant life, and yet has been sufficient to bring about a disintegration of the soils to great depths. The sparse herbage, luxuriant at times, is not sufficiently rank to make perceptible drafts upon this supply of plant food, and when at long intervals the rainfall occurs in proper seasons and quantities the yield from the cultivated fields is surprisingly large.

The area of this fertile land is far greater than that of any one of the States of the Union, and while the outlines can not be drawn with exactness, yet, in a general way, it may be said that the extent is from one-eighth to one-sixth of that of the whole United States. Within this vast tract, which embraces portions of Montana, North Dakota, South Dakota, Nebraska, Kansas, Colorado, New Mexico, Oklahoma, and Texas, thousands of families are resident, and there is

"room for millions more." (Fig. 31.) The one condition requisite for success is that of obtaining and utilizing a sufficient amount of water to supplement the deficient rainfall.

The Great Plains can be characterized as a region of periodical famine. Paradoxical as it may be, the countries where great famines occur are not those of sterility, but rather those of excessive fertility and of salubrious climate, inviting a dense population. Like other parts of the globe where dearth is apt to occur, the soil of the plains is extremely rich, the climate agreeable, everything physical invites a large population and an increase of animal and vegetable life, save in one essential, and that water. Year after year the water supply may be ample, the forage plants cover the ground with a rank growth, the herds multiply, the settlers extend their fields, when, almost imperceptibly, the climate becomes less humid, the rain clouds

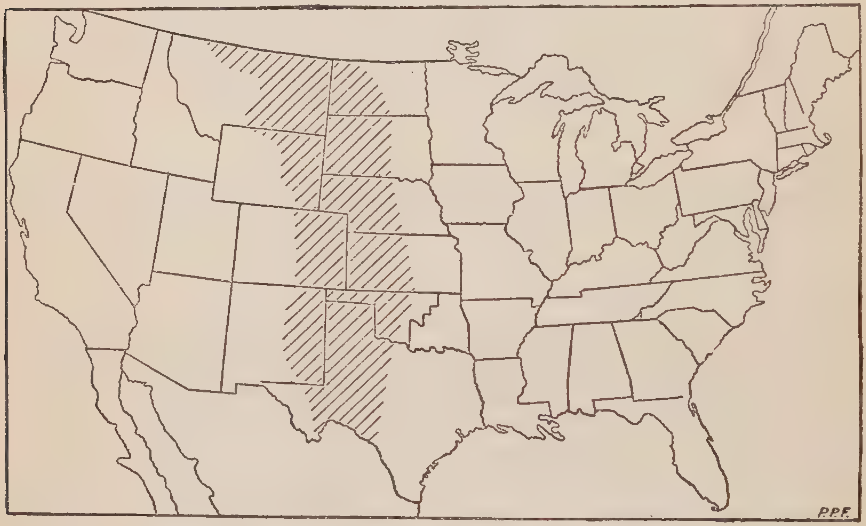

FIG. 31.—Diagram illustrating the relative location and extent of the Great Plains.

forming day after day disappear upon the horizon, and weeks lengthen into months without a drop of moisture. The grasses wither, the herds wander wearily over the plains in search of water holes, the crops wilt and languish, yielding not even the seed for another year. Fall and winter come and go with occasional showers which scarcely seem to wet the earth, and the following spring opens with the soil so dry that it is blown about over the windy plains. Another and perhaps another season of drought occurs, the settlers depart with such of their household furniture as can be drawn away by the enfeebled draft animals, the herds disappear, and this beautiful land, once so fruitful, is now dry and brown, given over to the prairie wolf. Then comes a season of ample rains. The prairie grasses, dormant through several seasons, spring into life, and with these the hopes of new

pioneers. Then recurs the flood of immigration, to be continued until the next long drought. This alternation of feast and famine is in Europe and the East as old as history and bids fair to be repeated upon our Great Plains unless American ingenuity, patience, and skill shall devise means of successful irrigation.

The first question that the farmer on the Great Plains asks when confronted with the problem of irrigation is, "Where can I get the water?" Sometimes the reply is obvious. There is a perennial stream which can be reached. But in a great majority of cases this is the first and greatest difficulty to be overcome. For each locality there are various solutions to the problem. In some cases water can be found underground at moderate depths. For example, in many of the valleys, especially in those of the larger streams, wells reach an abundant supply at depths of from 10 to 20 feet. But the area of the valleys is relatively small as compared to the whole extent of the Great Plains, and on the "uplands," as the broad divides between the rivers are commonly known, water can be had, if at all, only at depths of from 100 to 300 feet, or even more. Here, where the supply is small and must be lifted through considerable heights, the storage of storm waters must be considered. In rare instances it is possible to obtain a supply from deep artesian wells, which flow continuously a stream of fresh water. Unfortunately, the conditions governing the distribution of artesian wells are comparatively restricted, and these can be had only here and there throughout this region. The methods of water supply may, as far as the Great Plains region is concerned, be classified as those by gravity from perennial springs and streams, by pumping from rivers or underground sources, by storage of storm waters, or from artesian wells. Sometimes it is possible for the farmer to choose between two or even more of these ways of obtaining water, but as a rule he is limited to one.

Comparing the Great Plains and the arid region, there are to be noted many contrasted points which modify the practice of irrigation. These arise from the strikingly different forms of each country, its physical character or topography. In the arid regions the arable lands are mainly in the valleys or partly surrounded by mountains from which perennial streams issue with rapid fall. This facilitates the construction of canals built above the level of the fields, furnishing by gravity a relatively large amount of water. On the other hand, on the Great Plains are boundless tracts of fertile soil with no water within sight except at rare intervals after heavy storms. The underground supplies, usually small in amount, are widely distributed and can not be concentrated at any one spot.

The temptation to the settler is to make his farm as wide reaching as the horizon, and to spread his efforts over hundreds of acres. The ever-recurring droughts stimulate him to try and till more land, in the hopes that he may recoup his losses in a fortunate year. He is in

a certain sense a gambler, staking everything upon luck, and with the chances against him. With his desperate eagerness to regain in one season what he has lost through many years, it is almost impossible for him to see that his only hope of permanent success lies in limiting his operations to a comparatively few acres, and in cultivating these carefully and safely by using the small amount of water which, with great care and some expense, he may be able to secure. With his large conception he can not content himself with petty details. The stern logic of facts, however, is slowly convincing him that, in spite of the wealth of land, success lies only in attention to little matters. He must go back to the trivial economies of older lands, saving and using with judgment every drop of water which falls upon his field, or which can be brought to the surface from underground. This is the hardest lesson, and one which many men can not learn, preferring to emigrate rather than adopt what seems to them an un-American intensive farming.

WESTERN KANSAS.

The conditions upon the Great Plains are epitomized in western Kansas, and therefore a brief discussion of this area may not be out of place. It may be asked, why should further efforts and encouragements be given toward the development of agriculture in such regions? Has the world not heard enough of droughts and crop losses, of famines and suffering, of abandoned farms and worthless Kansas mortgages? Why interpose to prevent the country from going back to its former conditions? It was, and can be, a magnificent grazing land. As a stock range it will contribute to individual and general wealth without great risk of hardships and losses.

In answer to such questions and assertions, it is not enough to point to the hopes of persons desirous of selling out or to the too sanguine expectations of those who, encouraged by occasional success, have persisted in their efforts to make homes. It must be shown that there are substantial foundations for such hopes and expectations; that there actually exist resources worthy of better directed and more prolonged endeavors.

The conditions prevailing in western Kansas are not unique. The rich soil and capricious rains are found over vast areas, embracing, as before stated, portions of at least ten States. Ultimate success or failure in this locality encourages or retards home making in others. The struggles in western Kansas are, therefore, not without interest to the nation as a whole, for if once victory is assured, hundreds of communities will be benefited. Public interest is drawn here because attempts at settlement have been made in greater numbers than elsewhere, experiments have been conducted on a larger scale and in a character more varied, and the difficulties now appear to be more nearly overcome. Thus, it seems proper, as an introduction to general

investigations in the subhumid Great Plains region, to give first attention to western Kansas, to mention the results of trials and failures, and to outline what seems to be the road to success.

At least two things have been clearly proved. One of these is that the soil is very rich; the other is that the ordinary methods of farming are not adapted to the climatic conditions, and the farmer must laboriously unlearn much that he has acquired elsewhere. By repeated failures it has been shown that he must adjust his methods to fit more nearly the requirements of nature.

Hilgard has emphasized the fact that the soils of the arid and subhumid regions are, as a rule, as good as, if not better than, the best of those of humid lands. It is incredible that, with these great natural advantages of soil and sunshine, American ingenuity and persistence can not find a way to overcome in some degree the evil results of deficient or capricious rainfall. This is the great problem which the inhabitants of the subhumid plains have before them, and one to which the General Government can properly give attention. Not only is the prosperity of several States concerned, but, even more than this, the United States is the great land owner, still possessing many millions of acres of rich soil which should be put to better use than that of furnishing scanty forage. Such lands "deserve the most earnest attention both of agriculturists and of students of natural economy, for in them lie possibilities for the abundant sustenance and prosperity of the human race that have thus far been almost left out of account. While it is true that irrigation water may not be practically available for the whole of the arid (and subhumid) regions of the globe, so much remains to be done in the study of the most economical use of the water, of appropriate crops, and of methods of culture that even an approximate estimate of actual possibilities in this direction can not yet be made. At all events it is of the highest interest to study the problem of the reclamation of this intrinsically rich land in all its phases."[1]

IRRIGATION ESSENTIAL.

The settlements upon the Great Plains have proceeded gradually westward from the well-watered Mississippi and lower Missouri, advancing step by step up the gradual slope which extends toward the base of the Rocky Mountains, and pushing by slow degrees into the well-defined subhumid regions. The farmers have been tempted on and on by the fertility of the soil, which, instead of decreasing in richness, has been found to be equal, if not superior, to the lands washed by frequent rains. During the years or series of years in which the rainfall was more abundant or better distributed through the growing season the agricultural areas have leaped forward from

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[1] Prof. E. W. Hilgard, Steppes, Deserts, and Alkali Lands. Popular Science Monthly, p. 609, March, 1896.

county to county toward the west, and the farmers have deluded themselves with the belief that with the breaking of the prairie sod, the building of railroads, and the advent of civilization the climate was becoming more favorable to their operations.

Succeeding years, with a rainfall at or below the average, have beaten back or driven out many of the financially weaker or more easily discouraged of the settlers, and thus the tide of emigration has ebbed and flowed, each succeeding wave in general less vigorous than the first. Such vicissitudes, however, can not lead to prosperity and contentment. It is evident that they can not continue indefinitely, and that there must be a better adjustment of man to his environment, or he will be the loser in the end. Temporary or trivial expedients will not suffice. The heavens have been bombarded in vain, both with supplication and with dynamite. Somewhat slowly and unwillingly public attention has at last settled itself upon irrigation, and in this seems to be the salvation of the country. The water supply at best is small and its source and availability have by no means been self-evident. There are a few perennial streams within this vast area, but these attain notable size mainly at points where the conditions are such that the water can not be diverted and used economically or efficiently.

The widely distributed and yet relatively small supplies of water to which reference has been made are in the pervious, unconsolidated rocks or sands underlying portions of the Great Plains, especially along and in the vicinity of the broader river valleys. The problem of how best to bring these waters to the surface and utilize them is that which peculiarly distinguishes the Great Plains. The solution is best seen in western Kansas, for here hundreds of individual efforts have been made and success has been attained to a larger degree than elsewhere.

Almost anyone can irrigate with plenty of water. In other words, where a considerable volume is to be had at any one point within the arid or subhumid region a very moderate exercise of skill and judgment will enable the farmer to produce a crop of some kind. He can hardly fail to raise something, even though he drowns out a part of his field and leaves another part too dry. There must generally be some portion upon which the crops are remunerative. On the other hand, where, as in western Kansas, the water must be pumped from underground or stored in reservoirs, every gallon means a certain outlay. The quantity is usually limited, and a high degree of skill and judgment is required in order to utilize this water to the largest possible degree and produce a crop whose value shall repay not only the labor of cultivating, but also the cost of the water applied. In the case of the little ditches constructed from the mountain torrents in the arid region, a comparatively small outlay of labor was required in order to bring a considerable stream to the agricultural land.

Where the water is to be pumped, however, not only labor, but some capital, must be invested and continued to be employed until the crop is ready for the harvest. Since this first investment is usually large, and severely taxes the ability of the individual farmer, it is of vast importance to him that every step be taken in the right direction and that he make no mistakes.

In the subhumid region, especially where crop failures year after year have discouraged the farmers and have brought them almost to penury, the few hundred dollars required to start a small irrigating plant is a very great sum, and if not rightly expended may mean absolute ruin and loss of homestead. It is therefore especially important that in such undertakings no mistake be made. In the valleys of the arid region, if a farmer has not properly located his ditch, it may be possible for him to alter and improve it by his own labor or by assistance from his neighbors, but in the case of machinery or appliances used for raising water changes or alterations are far more difficult, if not impossible.

The attitude of the people of the subhumid region toward irrigation has been peculiar. They at first deemed it absurd, injurious, or impossible, and the man who held that irrigation was the proper and best thing was denounced as a public enemy and as casting discredit upon the region by advertising its disadvantages to the world. If he persisted in his unpatriotic course, it was considered enough to ask the question, "Where is the water to be had; even if irrigation is of value, where are the rivers from which to derive the supply?" If for answer attention was drawn to the ground waters and to the possible storage, the idea was regarded as laughable, and the advocate of irrigation was again asked, "How can you irrigate a section or even a quarter section by such trivial means?" If in reply the scoffers were told that it was not proposed to irrigate large areas, but to confine the attention of the farmer to 40 acres or even to 10 acres, contempt for such methods could scarcely find expression in words.

The idea that any man on the boundless plains would concentrate his energies on 10 acres has seemed ridiculous. Yet this is what stern necessity is compelling the farmer to do, and is making him unlearn his old habits and methods, relentlessly forcing him to abandon the cultivation of great areas, turning them over perhaps to grazing, and giving his main attention to the few acres almost within a stone's throw of his door. As a rule, the most successful men are those who have learned this lesson well, who have tried to do a little less than they considered could be done well, and who have practiced an untiring perseverance in adopting better methods in applying water and in cultivating the soil.

Within the past few years, or even months, public sentiment has undergone so great a change, from ridicule and skepticism to confidence in irrigation, that there is danger of rushing to the other

extreme. It is now generally recognized that irrigation is practicable at many localities, and with the enthusiasm that characterizes new movements, its sanguine advocates make excessive claims. They attempt to show that a great part, if not all, of the country can be irrigated, that water can be had almost anywhere, and that with a suitable irrigation plant the farmer is insured against all future loss and discouragement. The actual conditions are far otherwise. It is hardly probable that more than a small percentage of all the fertile land can be profitably irrigated, and experience has shown that, while irrigation is feasible and profitable, it is so only when something besides a supply of water is obtained. Successful irrigation means high-grade farming. It means the employment of intelligence and persistent labor. Unlike wheat farming, for instance, the work of the year is not concentrated into a few weeks or months, but for good results must be continued in one form or another almost every day. It is not sufficient to raise a single crop or a single kind, but if practicable two crops at least every year should be raised, one immediately following the other, and the diversity should be such that the water can be used to good advantage at short intervals. In other words, successful irrigation means diversified farming and the highest type of agriculture.

In order to start right, to employ the best device for getting the water, to use the water most efficiently and economically, to cover the largest area of ground thoroughly, to raise the best crops of fruits, and to carry on all the higher specialized methods which make irrigation farming profitable, it is necessary to have a larger knowledge than is possessed by the ordinary farmer and to keep abreast of the changes or improvements constantly being made. For this reason there is a wider field of study required and more opportunity for investigation both by the individual, the agricultural experiment station, and the experts of the General Government. In many respects our knowledge of irrigation has as yet advanced little beyond that of the early Egyptians. The process has been one of imitation or of individual tests through repeated failures.

SOURCES OF WATER.

The first and greatest problem is where and how to obtain sufficient water. Considering irrigated regions as a whole, the source of water, outweighing in importance all the rest, is that of the surface streams—the creeks and rivers. Secondary to this are the waters of intermittent streams or of occasional storms held by systems of reservoirs or huge tanks; and, third, the waters pumped or lifted from beneath the surface. A fourth class might be added, that of flowing wells, but these are so unusual in character and occurrence that they can hardly be considered as important factors in this method of agriculture. In western Kansas, and in the Great Plains region in general, stream

waters, as has been pointed out, are exceptional in occurrence, and can play but a relatively small part, while on the other hand the widespread distribution of water-bearing rocks renders wells of importance.

STREAMS.

The typical river of the Great Plains, and one of the first as regards the quantity of flood waters, is the Arkansas. This rises in the mountains of Colorado, flows in a course a little south of east into Kansas, continuing this direction for about 140 miles, then turns toward the northeast, and, describing a huge loop or bend, finally passes out of Kansas toward the south into Indian Territory. It drains, in round numbers, 24,600 square miles of Colorado before reaching Kansas. Of this area, that above Pueblo, 4,600 square miles, may be considered as mountainous, yielding a large perennial supply of water. The remaining 20,000 square miles are mainly plateaus and undulating plains from which an insignificant amount of water flows, except in time of flood, when vast volumes are poured into the stream, swelling it in a few hours to a raging torrent. The average discharge of the river at Canyon City, 70 miles above Pueblo, is a little over 800 second-feet, and at Pueblo 1,200 second-feet. The greater part of this water is used for irrigation, and during the spring and summer little, if any, passes into Kansas except that from a local storm or a cloud-burst. At one such time a quantity of water amounting to 30,000 second-feet or more was discharged for several hours, washing out bridges and causing general destruction. This amount was doubtless increased to 40,000 or 50,000 second-feet by the time it reached the Kansas line.

Along the Arkansas River in Colorado almost innumerable ditches and canals are taking out water, and in particular below Pueblo are the large irrigating systems under which is a considerable part of the agricultural population of the State. Many of the larger canal companies have constructed tight dams across the river capable of diverting the entire low-water flow of the stream. These are placed at intervals of from 10 to 20 miles or more. In the case of those possessing priority of rights, the entire discharge of the stream is taken and the bed of the river is left dry below the dam. In the case of others a certain portion of the water is allowed to pass by the dam under the direction of the water commissioners. Even though all the water is taken at one point, there is usually a sufficient amount of seepage to supply a small stream in the river bed, and this, increasing in the course of a few miles, furnishes, even in times of extreme drought, a small amount to the canal heading next below.

The aggregate capacity of the canals constructed or partially complete is far in excess of the ordinary flow of the river, and even by the employment of all the seepage water there must apparently be less than the amount needed for the cultivation of all the arable lands

under the extensive systems. Reservoirs are already being built to hold a part of the flood waters of the river, and it is highly probable that larger undertakings must be shortly inaugurated if a permanent supply is to be assured for canals now under construction.

Owing to the large and increasing utilization of the water of the Arkansas River in Colorado, the bed of the river is dry, through the greater part of the year, at points above the Kansas line, and there are comparatively few weeks during which a notable stream is flowing. As a whole, the time during which water is flowing in the river must decrease as irrigation above increases, and there will ultimately be a condition of things in which only the excess water of floods will pass down. Thus little dependence can be placed on the surface waters of the Arkansas River, and if irrigation in Kansas were dependent upon these it would be doomed.

The same general statement applies to the Platte River and to other lesser streams coming from high mountains and crossing the plains. The head waters of the Platte interlace with those of the Arkansas, and the minor tributaries flowing eastward and northward are to a large extent diverted into canals within the foothill region. The South Platte is thus deprived, for the greater part of the year, of all water long before reaching the Nebraska line. The North Platte, on the other hand, flows through a less populous region, and its waters have not been taken out in Wyoming to an extent to appreciably affect the annual flow. With the completion of many projects now on foot it appears probable that the large irrigation canals in the lower part of the river may at times be deprived of the full flow of the stream.

Besides the mountain rivers there are a considerable number of streams whose sources are well within the Great Plains. These derive their supply from springs fed by the rain water caught in thick deposits of sands and gravels. The waters thus obtained percolate slowly toward the lowest points, and are discharged in springs often perennial in character. These streams, however, have usually a gentle grade and can not readily be diverted into canals. Their waters, as a rule, are available only through some method of pumping.

STORM WATERS.

The localities which can be supplied by ditches from perennial streams are, as may be inferred from what has been said, relatively small when compared with the total extent of fertile land. Even along water courses which on a map appear to be of considerable size a careful survey shows that there are not many points where a reliable supply can be had. On the other hand, it is evident that from the size of the catchment basin and the known rainfall there must be a considerable volume of flood waters. The question at once arises whether a portion at least of this excess can be held for a few weeks or months until the time of need. It is well known that in other countries

irrigation is successfully practiced by means of water storage, and a large agricultural population prospers in a dry country where no living streams are to be found. Fortunately there are a number of examples of the utilization of this source of supply. Instances can be cited showing its feasibility and also indicating the disadvantages attending it and the obstacles to be overcome.

The reports showing the quantity of water flowing in the streams from time to time give the gross amount, both in flood and in time of drought. These figures, however, may be somewhat deceptive, especially those which give the maxmium discharge of the stream; and estimates of reclamation of arid lands should not be based wholly upon the maximum quantities, for the reason that it is obviously impracticable in many instances to store this great quantity of water. Storage projects at best are expensive, and to repay their cost and be of benefit to the farmers each reservoir should receive yearly a sufficient quantity of water to nearly fill it.

There are few localities where it will be possible to hold water from one year to another on account of the expense involved, and by far the greater number of projects must depend upon a constant supply of water. To do this it will be impracticable to construct reservoirs of such size as to hold the greatest flood, and as a general rule it may be said that engineers will favor a reservoir whose content is somewhat less than the average storm discharge of the stream. To illustrate: If the stream from which the water is to be taken discharges in one year three times as much as in the year preceding or the year succeeding, it will rarely be profitable to construct a reservoir of size sufficient to hold more than the smaller flood mentioned; for if built to hold the highest flood it may be only partially filled for several years in succession. Theoretically, it would be better to hold the highest flood and keep the water over from year to year; but practically there are so few localities where this can be done that these places may be regarded as exceptional.

The construction of reservoir dams of any considerable size should not be undertaken without consulting an experienced engineer. In fact, there should be a provision in the law of every State requiring supervision of such construction by competent State engineers. A dam is in one respect a defiance of nature, and all its forces conspire to pull the structure away sooner or later. It must therefore be carefully watched and afforded every protection, for a slight leak or the overtopping of the dam by an excessive flood may mean destruction of property, and even of human life.

The possible dangers from dams should not, however, act as a deterrent, any more than the occasional accidents upon railroads should be considered as sufficient argument for their restriction. With proper care storage reservoirs can be made, as shown by

the history of India, to last for many centuries, benefiting great communities. By using proper precautions a farmer may build upon his own land earth, rock, or timber dams which, if properly kept in repair, will be of incalculable benefit. (Pl. III.)

WELLS.

The most important source of supply for the Great Plains region is, and probably always will be, wells. There is reason to believe that considerable areas will be irrigated by gravity systems from the rivers and from storage reservoirs, large and small, built to catch the intermittent streams and flood waters; but taking all things into consideration, it will be conceded that ordinarily wells can be had over a larger area and possess such advantages that they must come first in the development of agriculture by irrigation on the plains.

Irrigation by water from a well, if the latter yields a good supply at moderate depth from the surface, possesses certain advantages over that from a gravity supply, in spite of the usually greater annual cost of procuring the water. The wells and the source of water are, as a rule, under the individual control of the irrigator. It is not necessary for him to combine with other men and to invest large capital in a complicated undertaking before he can receive any benefit. It is often possible for the farmer to dig or drill the well himself, and he can purchase, sometimes on credit if necessary, the machinery, windmill, or pump for bringing the water to the surface. Being under his own supervision, he can apply the water whenever in his judgment the plants need it, not being compelled to wait his turn or to take water at inconvenient times, whether day or night, according as it may be allotted under a large irrigating system.

Considering any one locality or farm, the question whether the water supply can be obtained is one for determination on the spot. It is often possible for the farmer to judge from the experience of his neighbors whether he can sink a well successfully at one point or another. If, however, his place differs widely in general location or in other conditions, so that he can not safely use the experience of others, then he must either trust to chance and dig his well at a point where it will be most convenient or, if practicable, consult some geologist or other person who has made a careful scientific study of such matters. In determining upon the location for a well it is generally useless to consult the professional well driller, unless he has put down other wells within a few miles and has considerable local knowledge. It seems hardly worth stating in this connection that money expended in the employment of the so-called "water witches," or men who use the divining rod, is worse than futile, as it merely encourages fraud.

It is often assumed that because the plains have such a uniform outward appearance their underground structure must necessarily be as featureless. But, on the contrary, there is a considerable diversity

RESERVOIR AND WINDMILL USED IN IRRIGATION.

in the order of arrangement beneath the surface. In some places there are thick beds of sand and gravel filled with water, from which such quantities can be obtained as to lead to the popular statement that the wells are inexhaustible. On the other hand, large tracts have, at a short distance beneath the surface, impervious beds of shale of a thickness of a thousand feet or more, containing little water, and this usually brackish or strongly saline, so that wells sunk into it are valueless. All these conditions of underground structure are the results of different conditions prevailing in past geologic ages and are capable of exact definition and mapping by the skilled geologist, so that when once the area has been thoroughly studied there should be no uncertainty to perplex the individual farmer as to whether it will pay him to invest money in wells, or whether by going deeper he could improve his supply.

It has sometimes been asserted that water from wells is not as valuable for purposes of irrigation as that from rivers, because the latter, especially during spring floods, bring a considerable amount of silt, which, during irrigation, is carried out on the land and being deposited serves as a fertilizer. The importance of this effect is in the popular mind often greatly exaggerated. The greater part of the silt brought into a canal is deposited in the main ditches and laterals, filling these, and necessitating a considerable annual outlay to keep them clean. The amount of material which actually is deposited upon the cultivated land is in general insignificant, not being equal to a few loads of ordinary fertilizer. This has been pointed out by Prof. E. W. Hilgard.[1] He shows that even in the case of the Nile the mud deposited amounts to only about 5 tons per acre, and that similar lands irrigated by clear water are just as productive. It is not so much the fertilizing character of the sediment as it is the scarcity of rainfall and the consequent freedom of the soil from leaching, as well as the beneficial effects of the warm, dry climate, which produce the great crops.

Well waters possess a more decided advantage in their freedom from noxious seeds. In the waters of the ordinary ditches, deriving their supply from a stream flowing through several valleys, there is usually to be found a great variety of seeds blown in by the wind or picked up during floods. These are carried along into the laterals and out over the fields, causing plants to start, some of which are exceedingly difficult to eradicate. This is especially true if a new crop of weeds is allowed to gain headway after each irrigation.

METHODS OF OBTAINING WATER.

After the farmer has settled upon the source from which water for irrigation can be obtained, the next problem which he encounters is that of bringing the water to the point where it is to be used. If the

[1] Popular Science Monthly, March, 1896, p. 605.

source of supply is at a higher level than the land to be irrigated, this is usually a simple matter. This may be considered the rule throughout the greater part of the irrigated area of the arid region, as the water is brought by gravity through canals and ditches from streams diverted at some point higher than the lands to be irrigated and carried often by circuitous routes to secure a gentle grade. If water is stored in a small reservoir or tank on the farm, it can of course be conducted either through earthen ditches or by pipes or flumes, according to the undulations of the ground. In the Great Plains region, however, the greater part of the water for irrigation is to be found either underground or in ponds or streams whose banks are of such character that, as before stated, gravity ditches are out of the ques-

FIG. 32.—A homemade jumbo windmill.

tion, or where the lands to be irrigated lie above the usual water level. The great problem, then, of obtaining water is that of pumping it at a cost so low that this operation can be performed with profit.

The question of pumping water merely is not a difficult one. Devices for lifting water are older than written history, and various forms of pumps are used on almost every farm in the country, every citizen being familiar with a number of ways of lifting water. (Fig. 32.) But the question is not simply to lift the water. It must be lifted in large quantities, and, more than this, the cost of so doing must be extremely low—so low that it shall bear but a small proportion to the value of the crops produced. This last requirement is really the obstacle to the widespread development of agriculture by irrigation

upon the Great Plains. There the distances are great from farm to town and from the producer to the consumer, and the value of the crops are correspondingly low; so low, in fact, that undoubtedly many products are not worth what they have cost if the farmer's labor were considered as being paid for at moderate wages. To pump water, therefore, to increase the yield of wheat or corn which must compete with that raised in humid regions is obviously out of the question.

The cost of pumping the great quantities of water used in irrigation prohibits the raising of water to heights of much over 50 feet. There are, of course, exceptions to any such rule, especially in the case of windmills and of hydraulic engines or water wheels. Claims are made that irrigation water has been pumped or lifted to heights of 200 feet, but such instances are rare and not well authenticated.

PUMPS.

In considering what kind of a pump to use, the farmer must of necessity determine at the same time upon the motive power, for, while some pumps are independent and may be driven by almost any kind of an engine or even by animal power, others are inseparably connected with the actuating mechanism or are designed for some particular purpose, as, for example, a windmill.

The simplest device for raising water is the open bucket. This when suspended from a well-sweep or hung in various ways has been used from long before the dawn of civilization down to the present day. In India and Egypt, where human labor is exceedingly cheap, considerable areas are irrigated by water lifted by men using buckets or woven baskets. Such methods are of course inapplicable to this country, but by having the buckets driven by machinery there results one of the simplest and most efficient devices. This idea occurred to primitive man, and there are to be found throughout the Old World water wheels carrying buckets on their rims lifting water into elevated troughs, or buckets tied together in an endless chain by ropes and lifted by animal power. This latter is known as the Persian wheel, perhaps one of the most widely employed mechanisms for irrigation, of great antiquity, and yet reinvented in almost every rural community. These wheels, or bucket pumps, as now used for irrigation, consist of an endless chain of small buckets extending down into the well and up vertically to the height to which water must be delivered to flow out to the land. This height is in practice limited to about 20 feet. The buckets descending empty and ascending filled are discharged at the highest point. (Fig. 33.) The machinery for raising them may be driven either by horse power, as in the case of a thrashing machine, or by a steam engine. Windmills have been used but little for this purpose, owing to their varying speed. In this kind of pump the water is lifted with the minimum amount of friction and useless expenditure of energy.

A modification of the common Persian wheel used to a small extent for irrigation is the form in which the buckets, instead of moving freely upward, pass through a pipe or a long rectangular box in which they fit quite closely. Instead of being of bucket form, they may be flat, and are then known as "flights." These, ascending with considerable rapidity, carry ahead of them a body of water of which only a small proportion has time to run backward in the course of its progress from the bottom to the top.

By far the greater number and variety of ordinary pumps may be classed under the head of piston or plunger. These are almost infinite in number and are the kind ordinarily employed with a windmill. They depend for their action upon two or more valves and upon the lifting or displacing of the water by the alternate forward and back, or in and out, movement of the piston rod. In general principles these pumps are too well known to require description. In size they range from the ordinary pitcher pump, to be found at almost every country house, up to the massive water cylinders of the compound condensing engine built for great cities or for draining extensive mines. Their cost is as varied as their size and intricacy, and can best be ascertained by each individual consulting for himself the nearest dealer or the catalogues of well-known manufacturers. For irrigation such pumps are driven by windmills, by steam engines, or by gasoline or hot-air motors, and in some instances, notably in the vicinity of Grand Junction, Colo., and on the Yakima River in Washington, by water wheels. Although widely known and generally used for pumping, yet for purposes of irrigation they are apparently being supplanted to a considerable extent by valveless pumps, such as the Persian-wheel type or the centrifugal form.

FIG. 33.—Bucket pump operated by windmill.

The centrifugal pumps possess an advantage not only in being valveless, and therefore less liable to injury by sand and floating obstacles, but also in the fact that they run continuously in one direction and do

not have the reciprocating motion of the various forms of plunger. The principle of their action is that of a rapidly whirling body throwing objects from its surface. Blades of suitably proportioned fans are caused to revolve rapidly in the water, and the masses thrown away are confined in a box or pipe in such manner as to be forced upward or outward, their place being supplied by succeeding quantities. These pumps are designed not only for purposes of lifting water, but even for transporting mud, sand, and gravel, and therefore can not be seriously injured by the muddy water often used for irrigation. As a rule, they are driven by steam power, as their efficiency depends upon the rapidity of motion. Some forms of centrifugal pump, however, have been designed for use with horse power (fig. 34) and even for windmills.

Closely related to the centrifugal pumps are various forms of rotary

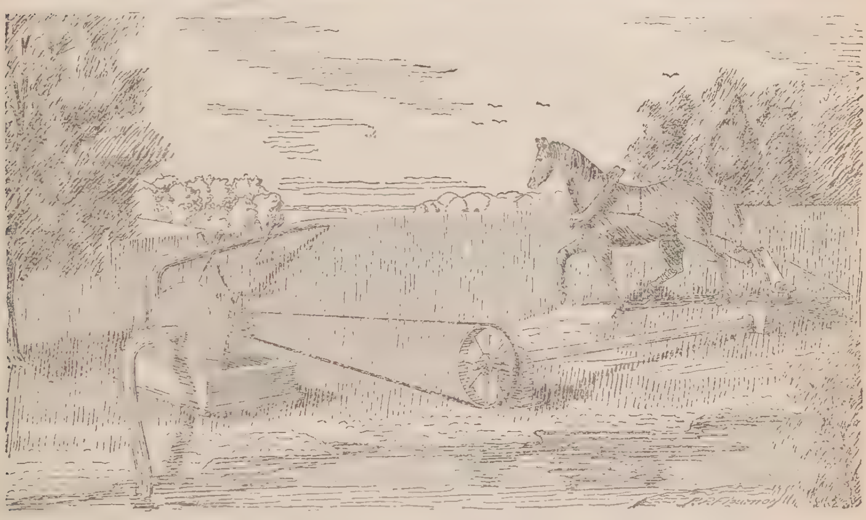

FIG. 34.—Centrifugal pump operated by horse power.

water engines, in which the moving parts, instead of traversing forward and backward the length of the cylinder, revolve around in it or in several portions of cylinders lying side by side. These also depend for efficiency upon rapid motion, and are so constructed that ordinary muddy water does not injure them.

Besides the types above described there are a number of hydraulic engines, such as rams or modified siphons, which depend for their efficiency upon the momentum of a column of water suddenly brought to rest. The ramming force of this large column sends forward a small part of the total amount to a higher elevation than that of the source of the main supply. These devices are useful wherever they can be installed, but they only deliver from one-seventh to one-tenth or less of the water which falls from a higher to a lower elevation, and they have therefore a limited use.

There are also offered to the irrigators a few pumps of low lifting power whose action is due to the condensing of steam and the consequent inrush of water to fill the vacuum created. These pumps, though extremely simple in principle, are often complicated in construction, and have in many instances failed to operate properly when not under the direct charge of a skilled mechanic.

In placing any form of pump in a well, care must be taken that the water flows freely toward it. For this reason it is desirable that wells from which considerable quantities of water are pumped shall be of sufficient size and shape to enable observation to be made of the behavior of the pump and of the level of the water surface. In many cases irrigators, misled by the common use of the term "underflow," have assumed that the water underground must flow rapidly to their wells and have sunk pipes into the water-bearing strata, connecting pumps to these as though they led directly to an open body of water. Powerful windmills have been provided and strong pumps attached in utter ignorance of the fact that the water can percolate but slowly through the ordinary sands and gravels. As a result, disappointment and loss of investment have ensued, and the farmer, instead of digging out a suitable well, has condemned the pumping machinery as defective. If an open pit had been provided in the first instance, he would at least have seen where the source of trouble lay and probably have been able to secure a larger supply of water by sinking numerous connecting wells.

WINDMILLS.

Of the devices for operating pumps for irrigation upon the Great Plains, windmills are undoubtedly the most important, and they will always remain so from the fact that the winds blow almost incessantly over this vast country. The power of the wind in the aggregate is something that can not be comprehended, and the windmills at best utilize only a small fraction of the force available in an infinitely small part of the moving air. As far as the total power is concerned, it is impossible to build machines too big, but mechanical skill soon reaches a limit. Practical application stops far short of the theoretical possibilities. A high degree of efficiency is not as essential as in the case of steam and other motors, because of the fact that there is power in excess and costing nothing. In the ordinary steam engines, however, fuel is the great item of expense, and the amount used must be cut down even at considerable outlay in first cost of machinery.

The forms of windmill are so diverse that a volume would be required to describe them, but for the purpose of raising water for irrigation the available types are comparatively restricted. There are, however, a considerable number of windmills on the market, many of which are being used successfully for raising water for agricultural purposes. It is, of course, impossible to recommend specifically any

of these, but the farmer intending to introduce irrigation should ascertain what kind of windmills, if any, are used in his locality or county, and endeavor to make use of the experience of others. If this can not be done, negotiations should be entered into with reputable firms who have been handling windmills for a number of years and whose business standing is such that they can not afford to sell or erect an inefficient machine. By taking these precautions the farmer will be reasonably sure of obtaining a good mill.

All things considered, the simpler the mechanism of a windmill the better. For use upon the Great Plains a complete metal construction is preferable to wood. One warning should be given, however, that extreme lightness and cheapness of construction should be looked upon with suspicion. There are a considerable number of mills on the market whose first cost is low, but whose expense for maintenance and repairs is extremely great.

The cost of a good windmill erected in place and attached to an efficient pump will of course be dependent not only upon the kind of machinery, but also upon the location of the pumping plant, the cost of freightage and handling being a relatively important item. In round numbers it may be said, however, that upon the Great Plains, at moderate distances from a railroad, a windmill with wheel 8 feet in diameter and suitable pump placed at a depth, say, of from 20 to 40 feet from the surface can be had complete for from $70 to $125, a 12-foot mill will cost from $100 to $200, and a 16-foot mill from $175 to $300. The cost of the individual items can best be ascertained from dealers' catalogues, as these fluctuate with the changes and improvements introduced. It is, as a rule, wiser in procuring an irrigating plant of this character to purchase a moderate-sized or small wheel at first, this being properly proportioned to the size of the pump and the amount of water to be had. If the farmer is successful with this smaller machinery, he can readily supplement it by other windmills at a later time, and by giving careful attention to the details of a small mill and limited acreage he will have greater chances of success.

Attention to details is, in fact, the keynote to good fortune, not only with the windmills and other machinery, but in the practice of irrigation itself. The windmill is a piece of machinery which, with moderate care and the exercise of common sense in keeping it oiled and properly adjusted, will last for many years. But no matter how simple or how strong, it can not be expected to run month after month without care. It has sometimes been assumed that irrigation is the lazy man's way of farming, and that all there is to be done is to procure a supply of water and let it flow upon the ground. It is through this mistaken idea that so many failures have been made upon the Great Plains. It does not follow that where the rainfall is slightly deficient all that has to be done is merely to supply this shortage. Far more than this is essential. Not only must all the devices for getting the

water to the ground be kept in constant order, but the soil itself must be given unremitting attention in cultivation after each watering.

As a general rule, it may be said that the fast-running windmills with backgearing are most successful. In these the pump rod is not connected directly with the shaft of the mill, making a stroke for every turn of the wheel, but a gearing is interposed, with the result that usually two or more revolutions of the wheel are required in each stroke of the pump. This reduces the resistance to the turning of the wheel, allows it to run in a lower wind, and thus results in the pump being operated on an average for a greater number of hours per day. If a plunger pump is used, it is desirable to have one with a relatively long stroke, so geared that in moderately high winds the motion will not be so rapid as to cause the machinery to pound at the beginning and end of each stroke. As ordinarily constructed, a considerable portion of the force of the windmill is employed destructively in a rapid succession of sudden jerks on the pump rod in its alternate up and down motion. For this reason a continuous-running pump, such as a centrifugal, would be more efficient if the driving power were uniform.

STEAM AND OTHER ENGINES.

The most obvious means of driving a pump, after the windmill, is the steam engine. Many farmers have already an engine for thrashing purposes or for other work on a farm. It is comparatively a simple matter to use this in driving a suitable pump, and the expense is in many localities so low that it is done with success. Where, however, fuel is expensive, as it is liable to be upon the Great Plains, or where it is necessary to employ a man of some considerable skill to run the engine, the cost may be prohibitory. Theoretically, it would be practicable for a number of farmers having moderate capital to join together in the erection of a pumping plant similar to that constructed for city purposes. Many estimates have been made showing that under certain conditions of cost of fuel and efficiency of engines the first and annual expense for water is less than that from the average of the larger canals throughout the country. Practically, however, this condition has not yet been realized, and so far as can be ascertained there are no steam pumping plants in successful operation upon the Great Plains. A few have been erected, but from one cause or another these have not proved financially successful.

Next to steam come the gas or gasoline and hot-air engines. The makers of these claim that they can be used with great efficiency, and in a number of instances they are reported to be in active operation. Either the first cost or the cost of the gasoline and of repairs must be greater than admitted by the owners or else there are practical difficulties in their operation. The fact seems to be that up to the present time few of these pumping plants have been installed. These engines usually require very little care and attention while in good order.

STORING AND CONDUCTING WATER.

Having determined upon a well or similar source of supply and a method of raising the water to a height sufficient to cause it to flow to the land to be irrigated, the next point to be considered is that of reservoir and ditches. Where storm waters are employed, the location of the reservoir is governed by the slope of the land, and the construction of this, if of considerable size, should be under the supervision of a competent engineer. With the ordinary windmill irrigation it is usually the case that the reservoir can be placed where most convenient. It is therefore desirable to so locate the point of storage that the ditches leading from it will carry the water to all points of the fields to be irrigated rapidly, and yet without such great fall as to wash the earth.

PONDS AND TANKS.

The necessity of a place for storing water where it is pumped or obtained in small quantities at a time arises from the fact that irrigation is only possible when a sufficient "head" of water is at hand to produce a stream of as great size and velocity as can be readily controlled by one man with a hoe or spade. It is impracticable to irrigate directly from the ordinary windmill, because of the fact that the stream of water turned into a ditch may continue for hours or even days without wetting the ditch for a distance of more than 50 to 100 feet from the well. The water soaks into the ground as fast as it is pumped upon it. But if this same amount of water is held in a tank or earthen reservoir of sufficient size, and is allowed to accumulate during several days and nights of continuous pumping, there is then at hand a sufficient volume to make it possible to irrigate even the most porous of soils. The gate of the reservoir, when opened, allows a stream of such size to issue that only a relatively small proportion can soak into the ground on its way to the cultivated lands.

Upon the Great Plains the method in most general use for holding water is that of utilizing small artificial ponds with earthen walls. In a few instances wooden tanks are used, constructed of staves held in place by iron bands, and similar to the water tanks constructed by railroad companies. The size of these latter, however, is limited and their cost relatively great, their disadvantage in this direction more than outweighing the economy effected by reducing the loss from leakage and evaporation.

In locating and constructing a small earthen pond it is necessary to consider not only the convenience of getting water into and out of it, but also the conditions which determine the losses. The greatest of these is through leaks in the sides or seepage through the bottom, and next to this is evaporation. This takes place only from the surface of water, and therefore the waste in this direction can be reduced by making the surface as small as possible relatively to the

volume of water held. If two reservoirs are constructed, one 100 feet square and holding water to the depth of 1 foot, the other 50 feet on each side and holding 4 feet of water, the loss by evaporation from the first will be four times as great as from the second, because it exposes four times the surface area. That this loss from evaporation is a matter worthy of consideration may be seen from the fact that in the Great Plains region, with its dry winds and bright sunlight, the loss of water each day during the summer may be from one-quarter to one-half inch in depth, and during windy days may be upward of an inch. If, however, the depth of the reservoir is increased in order to diminish losses by evaporation, there is danger of increasing the pressure to such an extent as to force water out in leaks through the banks or bottom. Greater care must therefore be taken in construction.

In order to prevent loss of water by leaking, it is desirable to select, if practicable, a place where the soil or subsoil is composed of a rather compact clay or of clayey loam. If, however, it is impracticable to find the right kind of soil at the desired elevation, then the reservoir can be built, but greater caution must be exercised. The size must depend upon the amount of water to be had. As a rule, the reservoirs on the Great Plains are from 50 to 100 feet across. In shape they are circular, oblong, square, or rectangular. The circular form offers the advantage of presenting the least amount of surface for a content of a given quantity. The same is true of the square form as compared with the rectangular. Some irrigators, however, consider that either the oblong or rectangular shape is preferable to the circular or square form, because, if constructed with the long diameter or width across the path of the prevailing winds, the waves created are smaller and less destructive to the banks. This is a matter of considerable importance where these are built of extremely fine, friable material.

Having determined upon the location, shape, and size of the reservoir, the first operation is to plow up and strip off the sod and surface soil where the banks are to be placed. All the sods, roots, and litter should be cleared away and the ground plowed, in order to make it possible to bind the new earth thoroughly with the undisturbed subsoil. Earth is then hauled in by scraper or wagon and dumped upon the foundation thus prepared. It should always be brought in small quantities and thoroughly trampled by the horses or pressed down by the wagon wheels before another layer is put in place. If practicable, it is desirable, in building the reservoir walls, to raise the outside edges slightly above the center of the wall and let in, from time to time, sufficient water to thoroughly wet the earth, causing it to settle more compactly.

The width of the foundation will depend upon the height of the wall to be built. It is usually at least three times the latter, so as to allow gentle slopes both on the inside and outside of the reservoir. It is

preferable to have slopes of at least 1½ to 1, that is, for a distance measured horizontally on the ground of 1½ feet the rise should only be 1 foot. The top of the reservoir banks should be at least 2 feet wide. If, therefore, the bank is 5 feet high, the slopes on each side will extend 7½ feet. Adding to this the width of the center will make 17 feet in all for the foundation. Earth for building a wall should not as a rule be taken from inside the reservoir, as this serves to lower the bottom and may cause it to leak, or by being below the general level the pond can not be completely drained.

In building the walls one of the first things to consider is the outlet. This should be placed in such a position that the water will be delivered conveniently to the ditches, and its position should be so low that it will completely empty the reservoir. This outlet should be provided with a valve or gate on the inner side, so arranged that it is accessible at all times. It is usual to construct this outlet of boards or plank in the form of a long box of from 8 to 18 inches in width and height. For permanence it might be better to use a metal pipe, but it is probable that the wooden outlet will serve for a sufficient number of years.

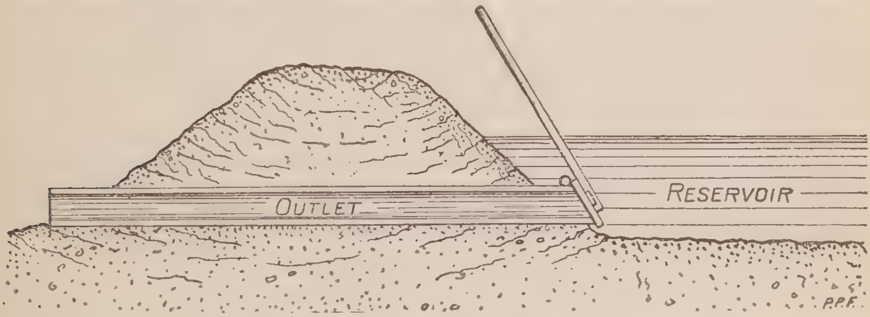

FIG. 35.—Section of reservoir bank showing outlet.

Having placed the outlet box or pipe in proper position, great care must be taken in building the wall at this particular place to secure a tight joint. Clay should be carefully tamped around and under the box, and as an additional precaution it is well to provide the box with wings or ribs projecting outward into the earth bank and preventing the percolation of water along the contact plane between earth and the wood or metal. The gate on the inside end of the outlet may be of any one of a great variety of forms, from a simple board placed securely against the end to the expensive metal valve used for city purposes. One of the simplest and most efficient gates in use consists of a broad plank covering the end of the box, which is cut off in such a position as to slope diagonally upward and toward the bank. The place of contact between the end of the box and plank covering it is lined with leather or some similar substance, insuring a tight joint. The plank covering is hinged on the upper side and is extended diagonally upward by a stout bar. When this is grasped and pulled toward the bank, the valve is opened against the pressure of the water, and when the bar is released it is automatically closed. (Fig. 35.)

After the reservoir walls are built they should be protected against the washing of the waves. This can be done by placing heavy sod upon them, or, better, by covering them at the water line with broken rock if this can be had. An efficient form of protection is made by roughly weaving willow twigs into a mat and holding this in place by stone or large sod. In course of time the willow takes root and holds the soil in place. In a small reservoir old pieces of plank thrown upon the water will often suffice, as these drift over to the side exposed to the waves and break their force.

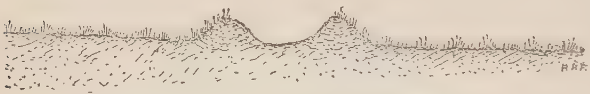

FIG. 36.—Section of field and lateral ditch.

The next step is to render the bottom thoroughly tight by what is known as puddling. If the soil is clayey, it may not be necessary to resort to this, but if composed of a light, sandy material there may be necessity for considerable care and for the exercise of much patience before the reservoir will be made reasonably tight. Puddling is accomplished by letting in an amount of water sufficient to make mud and then driving animals round and round until with their feet they have completely worked up all portions of the bottom, destroying the porosity by trampling fine material into every minute orifice. If there is not a sufficient amount of clayey material to form a muddy mass, then it will be necessary to haul in a few loads of clay. Short straw, litter, and manure can also be used to advantage in a sandy soil. By continuing this process of puddling and adding such materials a reservoir, even on extremely loose soil, can be made reasonably tight.

DITCHES AND FLUMES.

From the reservoir, whether constructed on a large scale to hold storm water or of small size to receive the discharge from a pump, there must be provided suitable means of conducting the water to the land. The simplest, cheapest, and most widely used is the open earth ditch (fig. 36) built in such a way as to have a gentle, uniform grade sufficiently great for the water to flow with rapidity and yet not to wash the banks. As no natural surface is absolutely uniform, it is necessary, in order to secure this grade, that the ditch wind about, following the contour of the surface. It is desirable, however, on account of economy of expense and of water, that all ditches should be as nearly straight as possible, and to save distance it is sometimes necessary to build up the ditch upon a mound (fig. 37) or, if

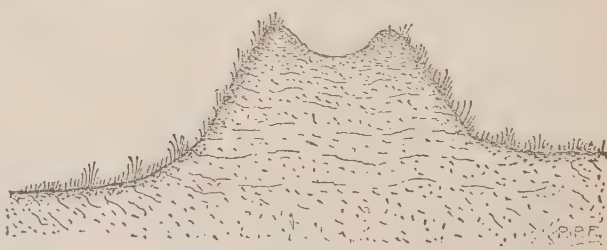

FIG. 37.—Section of raised ditch.

the depression to be crossed is too great, to construct a flume. It would of course be better to use a pipe laid directly from the reservoir to the point where water is to be distributed, but the expense, even of the cheapest forms, is too great to justify their use to any considerable extent for such crops as are raised upon the Great Plains. In California where the citrus and other semitropic fruits are produced, with a value of from $100 to $200 or more per acre, and where water is exceedingly expensive, pipes of wood, earthenware, and wrought and cast iron are largely used.

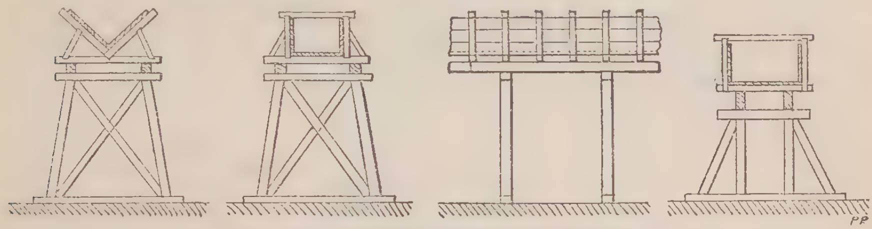

FIG. 38.—Sections and elevations of flumes.

To lay out a ditch, if a considerable distance is to be traversed, it is desirable to use a surveyor's level and run upon a determinate grade. If this is not practicable and the farmer has not had sufficient experience to judge grades by the eye, a simpler device can be used. This consists of a straightedge or stiff board 16 to 20 feet long, so arranged that a carpenter's level can be attached. If the fall is to be one-fourth or one-half of an inch per rod (about the usual grade), a little pin is fastened to one end of the board projecting downward this distance. At the starting point a small stake is driven into the ground and the end of the straightedge placed upon it. The other end carrying the

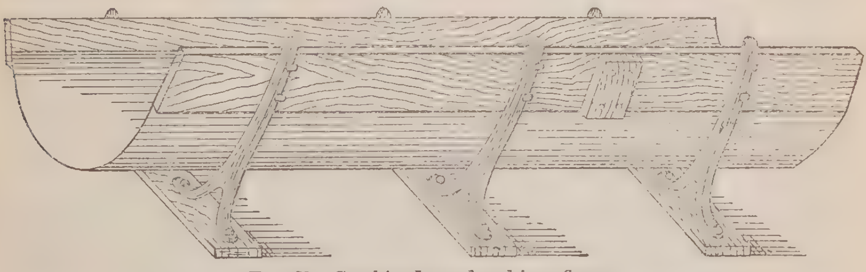

FIG. 39.—Combined wood and iron flume.

projecting pin is swung on a level until it strikes the ground, then a small stake is driven down until with the projecting pin of the straightedge upon it the leveling bubble is in the center. The straightedge is then carried forward, the upper end placed upon the second post, and the end with the grade pin on it swung about to determine the new position. After this series of posts or pins has been driven into the ground, the farmer can go over the line, straighten it out, or determine upon the necessity of constructing elevated ditches and flumes.

The ordinary flumes consist simply of open troughs or endless boxes (fig. 38) forming a portion of the ditch. They are built of boards or plank held in position and supported by timbers. Joints are usually made tight by pitch and oakum or by similar means. While in many cases flumes are indispensable and save the construction of long lines of earth ditches, they are usually a continual source of annoyance from leaking and require considerable attention to keep them in repair. The points where the flumes join the earth ditches are particularly difficult to maintain. It is necessary that the earth be very carefully tamped and that the flume be provided with wings in such a way as to make the union perfect. The section of the flume is usually rectangular, but it may be of a V shape, and occasionally, as in California, it is semicircular, this latter form requiring least lumber, but necessitating the use of iron bands or brackets. (Fig. 39.)

APPLYING WATER.

The methods of applying water differ widely, being dependent upon the character of the climate, crops, and soil, and upon the experience of the irrigator. The principles underlying the practice have never been clearly stated, and with the present knowledge of plant physiology and of soil structure it appears impossible for them to be. The greatest advance of irrigation will probably be along the line of exact information as to the behavior of water in the soils and of the influence of moisture upon plant growth and disease. This knowledge is needed, and although there is a large mass of statements of methods in vogue there has never been a comprehensive discussion of the matter such as leads to the presentation of simple and direct rules. It has been found, for example, that by applying water at one time and withholding it at others certain beneficial or injurious results have been obtained, but why these are so it is not possible to state clearly.

Rules for applying water applicable within the arid region may not be suitable for the Great Plains region or for localities farther east. There is considerable difference in the amount of sunlight received and in the dryness of the air. For this reason it has been found that so-called practical irrigators from Colorado and Utah have not made as great a success on the plains as men who have learned the art from experience on the spot. These farmers must in many instances unlearn the maxims they have acquired and note more carefully certain conditions which before they have neglected.

One of the first questions the farmer asks, after he has determined to try irrigation and has settled upon a source of water supply, is how much water will be needed or how much land can be irrigated with a given amount. This question appears simple, but like many others of its kind it is capable of a great variety of answers. It is a good deal like asking what is the average size of a boy. So much depends upon the surrounding circumstances of soil, climate, character of

FIG. 1.—METHOD OF APPLYING WATER THROUGH FURROWS.

FIG. 2.—FLOODING A WHEAT FIELD.

crop and means of applying water that most, if not all, of these must be known in advance. It is of course possible to take the statements of a great many farmers and, averaging them up, draw general conclusions, but these can not be applied to any special case without the exercise of considerable judgment, and before doing so certain technical terms or definitions of quantities must be clearly in mind. (Pl. IV.)

DUTY OF WATER.

The phrase "duty of water" is a term which has been devised to convey the idea as to the relation between the quantity of water and the area which can be irrigated by it. The duty of water may be expressed in three ways: First, by the rate of flow of a stream for a certain number of days necessary for the irrigation of 1 acre; second, by the actual volume of water in gallons, cubic feet, or acre-feet which, if properly applied, will suffice for an acre; or, third, by the total depth of water put at various times upon the surface. This third expression is similar to the second, but takes no account of the extent of the field, as, for example, we may say that a certain piece of ground requires 21 inches, that is, during the irrigating season a depth of water of 21 inches has in the aggregate been applied to the surface, usually in a number of waterings at intervals of several weeks. One of these expressions may be converted into the other conveniently by simple computations based upon the relation of one unit to another. In speaking of inches in depth, these must not be confused with the miner's inch, which is simply a rate of flow independent of the quantity.

The duty of water varies widely and can only be given in the most general terms. As before stated, it depends upon the climate, the amount of rainfall, the variations of temperature, the character of the soil and subsoil, the methods of cultivation, the kind of crops, and perhaps more than all upon the skill of the irrigator. Theoretically, it might be possible to ascertain just how much water a given plant requires under the ordinary range of temperature, and from this deduce the least quantity that can be used, but so many other matters must be considered that estimates of this kind have little more than a theoretical value. A certain quantity of water must be lost on the way from the stream or source of supply to the field, and again in the field before reaching the roots of the plant.

Although the duty of water varies widely in actual practice and is such an uncertain quantity, yet it is convenient to make certain assumptions in order to estimate the possible extension of irrigation from the given source of supply. There is a theoretical limit as to the amount of water required by plants, and it is impossible to successfully produce crops with any smaller quantity, but this limit is so far removed from present practice that it does not seem probable it will ever be reached. Moreover, as different varieties of plants require different amounts of water, it may be possible to introduce

kinds which will require a minimum supply and thus enable a larger acreage to be cultivated by employing the given quantity of water.

In the arid region, upon land irrigated for the first time and where water is to be had in abundance, a duty as low as 30 acres to the second-foot has been reported. This quantity of water flowing for, say, sixty days would cover an acre to the depth of about 4 feet. This may be regarded as one extreme. This amount, however, could not be used unless the surface drainage were perfect or the subsoil were largely composed of open gravels or sands, allowing water to escape freely, as it would quickly result in converting the country into a marsh. The excessive water would tend to carry away the rich qualities of the soil and wash it out until little of value remained. In some localities, where the earthy alkaline salts abound, this excessive irrigation or washing is resorted to in order to take away the injurious superabundance of soluble material.

The ordinary duty of water, as measured in the ditches leading to the fields in Utah, Idaho, and parts of Colorado, ranges from 60 to 70 acres to the second-foot. This quantity of water flowing for sixty days is equivalent to a depth of about $1\frac{2}{3}$ to 2 feet, and for ninety days to a depth of from $2\frac{1}{2}$ to 3 feet. This is very nearly the minimum duty as fixed by the State law of Wyoming, which requires that no allotment of water shall exceed 1 cubic foot per second for each 70 acres.

The highest duty of water is reached in California, where the quantities are usually given in miner's inches. The ordinary practice is 2 acres to the miner's inch, or 100 acres to the second-foot. From this as a minimum the quantity runs up to 4 or 5 acres to the miner's inch, and in some cases, as in the cultivation of orchards where water is very scarce and expensive, it is reported to be as high as from 8 to 15 acres to the miner's inch, or from 400 to 750 acres per second-foot. This quantity flowing for sixty days would cover the ground to a depth of from $3\frac{1}{2}$ to 2 inches, or for ninety days to from $5\frac{1}{3}$ to 3 inches. Where the soil is naturally retentive of moisture and has been once thoroughly saturated, it has been found possible by careful and continuous cultivation to attain success with orchards, vines, and some of the field crops with but one slight watering, or even without any, for a number of years in succession. In such cases the water duty may be given as extremely high. But it is hardly proper to consider such cases in connection with ordinary irrigation.

In the Great Plains region as a whole, where water is derived from underground sources or is held in storage reservoirs, it is necessary to reach a duty of water higher than that commonly found in case of water from large perennial streams, from the fact that the first cost is usually larger, the quantities to be handled are smaller, and the land irrigated is generally in the immediate vicinity of the source of supply. For irrigation during the first year the duty can hardly be estimated, because the thirsty soil is almost insatiable in its demand

for water, but after the ground has once been fairly well saturated an application of 20 inches of water in depth for the second year should suffice, and after that less and less, depending upon the amount of rain and the humidity of the air. The question of quantity of water is so closely connected with that of cultivation that no estimate can have any great value beyond giving broad impressions.

One of the most important points for the farmer to have in mind when planning his methods of irrigation is, in any event, to provide a sufficient supply of water. On the Great Plains, especially, and to a less extent throughout the arid region, there is a tendency to underestimate the duty of water and where expenditures are concerned to try to make a small supply go too far. This is not the case with the older irrigation ditches built by farmers from streams of considerable size, for there water is lavishly used and often to the detriment of the crops; but where pumping or storing water is concerned, or where the farmers purchase water rights, the tendency is to go to the other extreme and, relying upon theoretical considerations, try to cultivate land with an entirely inadequate supply. Between these two extremes lies the intermediate ground of success. Too much water will reduce the amount and quality of the crop, while too little will result in waste of energy and in disappointment through utter failure. Great injury has already been wrought to the development of irrigation through the excessive sale of water rights in storage enterprises or canals, where farmers have purchased acreage rights to which an inadequate supply was allotted. The proper development of pumping has also been retarded by overestimates of the capacity of the pumps and underestimates of the amount of water required, so that in actual performance, where ordinary difficulties and accidents were encountered, the pumping plants have been serious disappointments if not actual losses.

The methods of applying water can best be learned by the individual farmer through experience. They are not at all difficult, although in each locality certain details are to be observed, dependent upon the character of the climate, soil, and crops. The methods in common use throughout the West have been so often described and are so well given in an article by L. R. Taft in the Yearbook for 1895 that further discussion is hardly necessary. Emphasis should be given, however, to the fact that the first essential for an economic application of water is that of having the ground properly leveled or graded before cultivation and irrigation are begun. When this has been thoroughly done, the irrigation can be carried on rapidly and efficiently with a small quantity of water and the supply can be evenly distributed, each portion of the field receiving its share.

CULTIVATION.

The whole object of irrigation is to supply a sufficient amount of water at the right time, so that the plants will reach their highest

development or produce the finest fruit. This object will, however, be defeated unless irrigation is accompanied by proper cultivation. In fact, if one can be said to have more importance than the other, it is cultivation. This must be carried on usually to a far higher degree of perfection than in the case of nonirrigated crops, from the fact that in the practice of irrigation a considerable expenditure is involved, even at the best, and the largest returns should be realized in order to recompense this outlay. With ample water at hand, many of the conditions affecting crops are under control, and it should be possible by proper care to realize an ideal condition of yield and fruitage.

The farmer who imagines that by procuring suitable irrigating machinery or devices and by pouring water upon the fields he is thereby doing all that is necessary to insure a profitable yield is almost certain to be disappointed. This is only the beginning of his labors, for, except in the case of the forage crops or small grains, the application of water must be followed by thorough tilling, and this should be kept up until the soil is in a perfect condition of mulch. There are to be found all over the plains region farmers who have gone so far as to procure a windmill or other pumping machinery, and who have for a season let the water flow over their fields without care or judgment, drowning out parts of the crops, washing the soil in places, and allowing it to bake in others. These men, as may be expected, denounce irrigation as impossible or useless, not being willing to acknowledge that the fault lies in their own lack of attention to the soil after water has been applied.

In trying irrigation for the first time the farmer should attempt it upon only a small area, from 3 to 5 acres, and put as much labor upon these as he has been accustomed to spend upon many times that number in dry farming. If this is done intelligently, the larger yield will more than compensate for the added exertion. By giving careful attention to the needs of crop over a small area the farmer will soon learn to judge for himself as to when, with his conditions of soil and climate, plants actually require water. It is almost impossible in the present stage of our knowledge to give these definite directions, but it is practicable for the observant man to learn for himself while carrying on the cultivation so essential to success.

It should not be assumed from what has been stated that the benefits of irrigation are felt only in the more arid portions of the Great Plains. Such localities undoubtedly possess a certain advantage in that the sunlight is more intense, but this is a difference of a relatively small degree. On the eastern side of the Great Plains, and in fact over the adjacent prairie regions, irrigation can be and is being introduced with success. Viewed merely as a method of insurance against crop loss, the expense of procuring suitable methods of applying water at the right time can not be regarded otherwise than as a businesslike investment.

THE BLUE JAY AND ITS FOOD.

By F. E. L. Beal,
Assistant Biologist, U. S. Department of Agriculture.

GENERAL REMARKS.

Of the various birds that enliven the groves and orchards, few are more conspicuous than the common blue jay (*Cyanocitta cristata*) (fig. 40). Its loud and rather harsh voice, striking colors, and obtrusive actions attract attention when other birds equally abundant remain unnoticed. An accurate knowledge of its food habits is a matter of some importance from an economic point of view, since the bird is abundant and feeds largely upon grain and other hard seeds, although the proportion supplied by the farmer's crops has never been accurately determined. It has also been shown that the jay occasionally

Fig. 40.—The common blue jay.

preys upon the eggs or young of other birds, and some observers have declared it an habitual nest robber and thief, but the extent of its nest-robbing proclivities is unknown, and a detailed examination of its food is necessary in order to throw more light on these points.

The blue jay is distributed over the whole of the United States east of the Great Plains, from the Gulf of Mexico to Manitoba and Newfoundland. It remains constant in form and color throughout most of this region, except in Florida and along the Gulf coast, where a smaller race (*Cyanocitta cristata florincola*) occurs. While jays commonly resort to the forest to breed, they do not by any means confine themselves to the woods, but visit orchards, meadows, gardens, and

farmyards in search of food. They remain throughout the year in most parts of their range, and their beautiful blue plumage is particularly conspicuous in the fall and winter months, when the trees are partly or wholly denuded of foliage. Their saucy, independent airs, sprightly manners, brilliant colors, and jaunty, plumed caps have gained them many friends, in spite of the fact that their food habits are supposed to be somewhat detrimental to the interests of the farmer. So completely is this latter fact forgotten in the gloom and nakedness of winter that it is a common practice in many places, notably in New England, to place beds of chaff upon the snow into which corn is scattered each day in order to attract the jays. When the ground is well covered with its wintry fleece, they may be seen at all hours of the day eagerly pecking in the chaff for the welcome morsels, and their presence in the garden and on the lawn relieves to some extent the winter dearth of bird life.

The vocal powers of this bird, while by no means to be despised, are not as pleasing as is its plumage, and most of its notes can be considered agreeable only by association. Jays are more or less garrulous all the year, but are particularly noisy at harvest time when laying up a supply of food for winter. They also exhibit considerable powers of mimicry and imitate the notes of many other birds with considerable success. One which was kept in captivity by Mr. Sylvester D. Judd learned to pronounce several English names distinctly, as well as to give a schoolboy's yell and to whistle for a dog.

Blue jays have been charged with eating grain, devouring fruit, and destroying the eggs and young of other birds. It is also asserted that they devour numerous insects, and thus to some extent counterbalance the harm they do. Many cases of nest robbing might be cited, but it will be sufficient to give a few notes of field observers.

Mr. Henry M. Berry, of Iowa City, Iowa, claims to have seen blue jays suck the contents of four eggs of the wood thrush while the old bird was only a few feet distant doing its best to drive them away.

Mr. B. F. Goss, of Pewaukee, Wis., declares that they are the worst robbers of all, and that their destruction of the eggs and young of small birds is appalling.

Mr. T. J. Bull, of Hot Springs, Ark., writes: "While standing on the observatory on Hot Springs Mountain, I saw beneath me a pair of redbirds chirping in great distress, and also noticed a blue jay fly away. Upon looking more closely, I discovered a nest with one young bird in it. * * * In about half an hour the jay returned to the nest, picked up the young bird, and flew away with it."

In view of such explicit testimony from observers whose accuracy can not be impeached, special pains have been taken to ascertain how far the charges were sustained by a study of the bird's food. An examination was made of 292 stomachs collected in every month of the year from 22 States, the District of Columbia, and Canada.

EXAMINATION OF STOMACH CONTENTS.

One of the first points to attract attention in examining these stomachs was the large quantity of mineral matter, averaging over 14 per cent of the total contents. The real food is composed of 24.3 per cent of animal matter and 75.7 per cent of vegetable matter, or a trifle more than three times as much vegetable as animal (fig. 41). The animal food is chiefly made up of insects, with a few spiders, myriapods, snails, and small vertebrates, such as fish, salamanders, tree frogs, mice, and birds. Everything was carefully examined which might by any possibility indicate that birds or eggs had been eaten, but remains of birds were found in only 2, and the shells of small birds' eggs in 3 of the 292 stomachs. One of these, taken on February 10, contained the bones, claws, and a little skin of a bird's foot. Another,

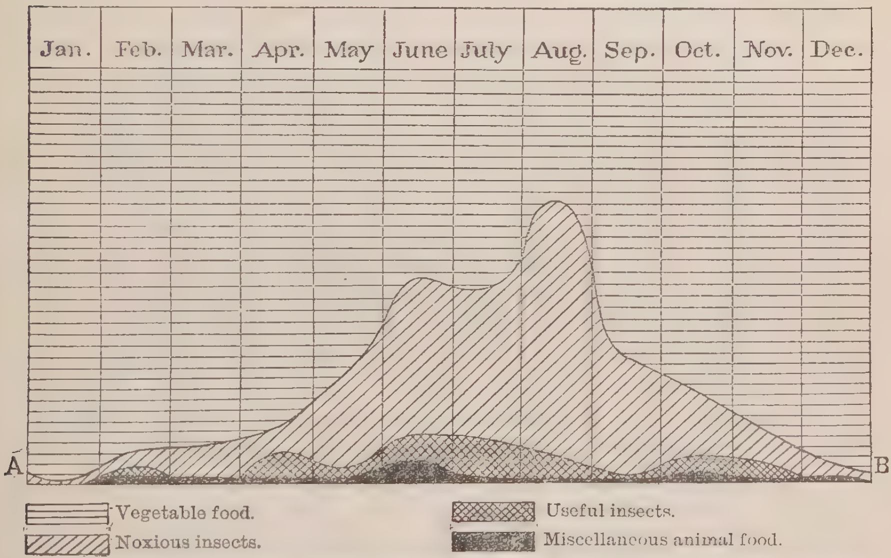

FIG. 41.—Diagram showing the relative amounts of vegetable and animal food eaten by the blue jay in each month of the year. The vegetable food is represented by the area above the line A B; the animal food by the space below.

taken on June 24, contained remains of a young bird. The three stomachs with birds' eggs were collected in June, August, and October, respectively. The shell eaten in October belonged to the egg of some larger bird like the ruffed grouse, and considering the time of year, was undoubtedly merely an empty shell from an old nest. Shells of eggs which were identified as those of domesticated fowls, or some bird of equal size, were found in 11 stomachs, collected at irregular times during the year. This evidence would seem to show that more eggs of domesticated fowls than of wild birds are destroyed, but it is much more probable that these shells were obtained from refuse heaps about farmhouses.

To reconcile such contradictory evidence is certainly difficult, but it seems evident that these nest-robbing propensities are not as general as has been heretofore supposed. If this habit were as prevalent as some writers have asserted, and if it were true that eggs and young of smaller birds constitute the chief food of the blue jay during the breeding season, the small birds of any section where jays are fairly abundant would be in danger of extermination.

The ease with which a bird's actions may be misinterpreted is well illustrated by the case of a stomach which was received with the legend "Eating robins' eggs," but which, upon rigid examination, failed to reveal even a minute trace of an egg. It is of course possible for a bird to eat an egg without swallowing any portion of the shell, in which case the soft contents would soon disappear from the stomach, but in view of the fact that such substances as dead leaves, bits of plant stems, and rotten wood, which are evidently swallowed accidentally with insects or other food, are constantly found in birds' stomachs, it does not seem probable that blue jays would discriminate against eggshells. To test this matter, four eggs of the English sparrow were offered to a jay in captivity. The bird at once seized the eggs and began to eat them, but when any piece of the shell, no matter how minute, was accidentally dropped it was at once picked up and swallowed, and several such pieces that were thrown to the farther end of the cage were also eaten, so that the shells with their membranes were entirely gone before the soft contents.

Besides birds, remains of small vertebrates were found in twelve stomachs, as follows: Fish and salamanders in one stomach each, tree frogs in four, mice in five, and a shrew in one. It is perhaps worthy of note that Dr. B. H. Warren failed to find a trace of any vertebrate remains in examining twenty-three stomachs of the blue jay, fourteen of which were collected in May, one in June, three in September, and five in October. (Birds of Pennsylvania, pp. 200–201.)

The jay kept in captivity by Mr. Judd showed a marked fondness for mice, and would devour them apparently with great relish. Another bird ate only a portion of dead mice and refused to touch live mice, preferring insects when it had an opportunity for choice.

INSECT FOOD.

Insects are eaten by blue jays in every month in the year, but naturally only in small quantities during the winter. The great bulk of the insect food consists of beetles, grasshoppers, and caterpillars, with a few bugs, wasps, and flies, and an occasional spider and myriapod. The average for the whole year is nearly 23 per cent, varying from less than 1 per cent in January to over 66 per cent in August, and gradually diminishing to 3.2 per cent in December. There is a remarkable increase in the quantities eaten in spring and summer, the percentage increasing from 28 in May to 44 in June, and from 46 in July to

66.3 in August. The molting season may account for the increase in August, but that in June is not so easily explained. The beetles found in the stomachs may be roughly divided into three groups: Predaceous beetles (Carabids); those belonging to the May beetle family (Scarabæids); and miscellaneous beetles, including about half a dozen families. Each of these groups forms a little more than 3½ per cent of the food. The greatest number of predaceous beetles were eaten in July, when they aggregated 10.25 per cent of the food of the month. The Carabids belong for the most part to genera with blunt jaws, such as *Harpalus*, *Cratacanthus*, and *Stenolophus;* only a few specimens with sharp jaws like *Pasimachus*, *Galerita*, and *Calosoma* were found, and it is probable that no great harm is done by the destruction of these beetles, as they are not entirely carnivorous and are therefore less useful, and the individuals are abundant.

Scarabæids reach their maximum abundance in the jay's food in August (11.8 per cent), although nearly as many (11 per cent) were eaten in June. They were mostly represented by the larger species, such as the goldsmith beetle (*Cotalpa lanigera*), the spotted grapevine beetle (*Pelidnota punctata*), the brilliant tumblebug (*Phanæus carnifex*), with many May beetles (*Lachnosterna*), and quite a large number of fruit-eating beetles (*Euphoria inda* and *E. fulgida*). At least five specimens of *Euphoria inda* were found in one stomach, amounting to 75 per cent of the whole food contents. It is worthy of notice that one stomach contained a nearly perfect specimen of the grapevine beetle and also the seeds and skins of the wild grape (*Vitis cordifolia*), and it seems probable that the bird visited the vine to feed upon the grapes, but finding the beetle swallowed that also. Beetles belonging to other families aggregate 16.3 per cent in June, the most important being a few leaf-eating beetles (Chrysomelidæ), some click beetles (Elateridæ), and a number of curculios (Curculionidæ). A dozen curculios, belonging to the genus *Balaninus*, were found in a single stomach, and three in another. As these beetles live on acorns and other nuts, it seems probable that the birds devoured them when looking for their favorite food, mast.

Grasshoppers, crickets, and locusts form about 4.4 per cent of the food; but they do not become an important element until July. They attain their maximum of 19.5 per cent in August, and continue in considerable numbers until December. If June can be called the beetle month in the dietary of the jay, August is the grasshopper month; and birds that eat these insects at all eat the greatest quantity at this time. Many birds that live during the rest of the year on food obtained from trees or shrubs come to the ground and feed upon grasshoppers in August. Caterpillars form an important element only in March, August, and September, and the greatest number, amounting to 11.4 per cent, were eaten in August. The kind of caterpillars eaten is of more interest than the number. The jay

apparently likes to take its food in large morsels, and as in the case of beetles, large larvæ, like those of the humming-bird moths (Sphingidæ), are selected whenever obtainable. In several cases a single specimen of these caterpillars more than 2 inches in length and nearly as large as one's finger was snugly coiled up in the stomach, almost filling the whole cavity. Eggs of insects were frequent, and those of the tent caterpillar moth (*Clisiocampa americana*) occurred in four cases. Dr. J. A. Allen has found these eggs in blue jay stomachs (Auk, XII, Oct., 1895, p. 383), and many years ago Dr. J. P. Kirtland called attention to the usefulness of this bird in destroying the larvæ of the tent caterpillar (Atlantic Monthly, XXV, Apr., 1870, p. 482). Many of the smaller species of caterpillars were quite hairy, and others rough and warty, showing that this does not render them objectionable. Mr. E. H. Forbush credits the blue jay with eating great numbers of eggs, pupæ, and larvæ of the gypsy moth, and he observed them carrying away the larvæ, which are hairy caterpillars of considerable size, apparently to feed their young. (Rept. on Gypsy Moth, Mass. Board Agr., 1896, pp. 214, 215.)

Insects of several other orders were found in nearly every month, and in July and August amounted to a little more than 11 per cent. Hymenoptera were represented by wasps and a few ants. One stomach contained a specimen of the pigeon horntail (*Tremex columba*), a very injurious wood-boring insect. Diptera, or flies, were found in only three stomachs. Hemiptera were represented by quite a number of stink bugs (Pentatomids), a few cicadas, and remains of coccids, or bark lice, which were found in two stomachs. Spiders occur frequently, myriapods occasionally, and snail shells were found in thirty-eight stomachs.

VEGETABLE FOOD.

As already stated, three-fourths of the blue jay's food consists of vegetable matter, which may be conveniently arranged in several groups: (1) Grain, mast, and seeds; (2) fruit; and, (3) miscellaneous.

LIST OF VEGETABLE SUBSTANCES FOUND IN STOMACHS OF THE BLUE JAY.

Grain and mast.—Corn, wheat, oats, buckwheat, acorns, chestnuts, beechnuts, hazelnuts, sumac (*Rhus*), knotweed (*Polygonum*), sorrel (*Rumex*).

Fruit and miscellaneous.—Apples, strawberries, currants (*Ribes rubrum*), blackberries (*Rubus*), mulberries (*Morus*), blueberries (*Vaccinium*), huckleberries (*Gaylussacia*), wild cherries (*Prunus serotina*), chokecherries (*Prunus virginiana*), wild grapes (*Vitis cordifolia*), service berries (*Amelanchier canadensis*), elderberries (*Sambucus canadensis*), sour-gum berries (*Nyssa aquatica*), hawthorn (*Cratægus*), chokeberries (*Aronia arbutifolia*), pokeberries (*Phytolacca decandra*), oak galls, mushrooms, tubers.

Grain is naturally one of the most important groups, and may be considered first. Wheat, oats, and buckwheat occur so seldom and in such small quantities (1.3 per cent of the whole food) that they may be dismissed with slight comment. Wheat was found in only eight stomachs, oats in two, and buckwheat in one. The wheat was eaten in July, August, and September; oats in March and July, and buckwheat in October. Corn was found in seventy-one stomachs, and aggregates 17.9 per cent of the food of the year. This is less than that eaten by the crow (21 per cent) or by the crow blackbird (35 per cent). In January the amount consumed reached nearly 56 per cent. It is perhaps fair to add, however, that about one-third of the stomachs taken in that month were from birds shot at a corncrib when the ground was covered with 3 feet of snow, and do not fairly represent the food of the month. Corn was also found in considerable quantities in February, April, May, and September.

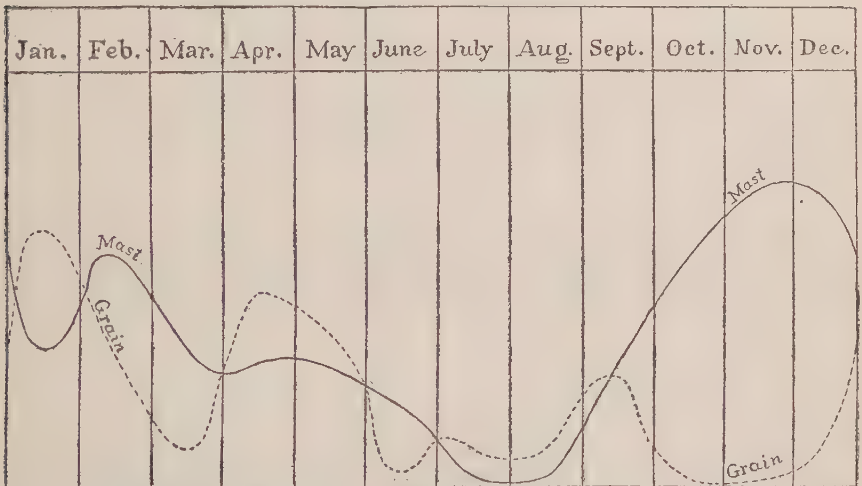

FIG. 42.—Diagram showing the relative amounts of grain and mast eaten by the blue jay in each month of the year.

Under the term "mast" are grouped large seeds of trees and shrubs, such as acorns, chestnuts, beechnuts, and others less conspicuous to the ordinary observer. Unlike corn, it formed a remarkably constant element, and aggregated more than 42 per cent of the whole food of the year. It was found in 168 stomachs, and varied from one-fourth to three-fourths of the total food in every month except July and August. The fact that it is eaten, not only in the late fall, winter, and early spring, when other food may be hard to obtain, but also throughout late spring, summer, and early fall, when fruit, grain, and insects are abundant, would seem to show that it is preferred. The consumption of mast exceeds that of corn in every month except January, April, July, and August; but only a small amount of either is eaten in these last two months. The test as to whether corn is preferred to mast

would seem to be furnished by the record in October and November. It must be admitted that throughout most parts of the blue jay's range both corn and mast are equally accessible during these two months. The cornfields are ripe for the harvest, and lie open and unprotected, where the birds can gather their fill without let or hindrance. The forests also furnish an incalculable quantity of acorns, chestnuts, chinquapins, and beechnuts, while the hedges and river banks teem with hazelnuts, and there seems no reason why the jays should not eat the food that they like. An examination of the stomachs will indicate best what they have actually eaten (fig. 42). Seventy-two stomachs taken in October show an average of over 64 per cent of mast, and eleven collected in November nearly 82 per cent, while the corn in each month aggregates only 1.1 and 0.9 per cent, respectively. It seems scarcely possible to draw any other conclusion than that the blue jays prefer mast to corn, or indeed to any other vegetable food, for they eat the greatest amount at a time when fruit, grain, and other things are most abundant. The record for December shows that the taste for mast, far from being satisfied, has rather increased, and attains its maximum of almost 83 per cent; while only 10 per cent of corn has been taken instead of several other seeds and fruits which were eaten earlier in the season. It was the custom of the writer, at his home in Massachusetts, to bait the blue jays in winter with chaff and corn in the manner already mentioned, and he observed that the birds patronized these feeding places only so long as the ground was completely covered with snow. No sooner did any considerable area of bare surface appear than the corn was discarded and no more birds were seen on the chaff until the earth was again covered with snow. The natural inference was that the jays found something on the bare ground, presumably mast, which they preferred to corn. It is possible that this fondness for mast may affect the distribution of certain trees to some extent. A jay flying with a nut in its beak may drop it in mid-air or carry it away and perhaps store it for future use. Acorns and other nuts may be distributed in this way, and it is probable that many isolated oaks and chestnuts owe their origin to accidents of this kind.

Jays show considerable taste in the choice of fruit. Apples were eaten only during January, February, and March, and consequently were merely frozen fruit left on the trees to decay, which should perhaps be reckoned as refuse rather than food. In the month of March the consumption is greatest, amounting to more than 32 per cent. Fresh fruit is eaten to a slight extent in May, but the quantity increases rapidly in June, and attains more than 39 per cent in July, and then gradually diminishes until it disappears entirely after October. The jay is often included with other birds in the charge of habitual stealing of cultivated fruit. Discarding apples which have no value, only four kinds of fruit are eaten which may be cultivated, namely, strawberries, currants, blackberries, and mulberries. No

cultivated cherries or grapes were found. Strawberries were found in three stomachs, currants in seven, blackberries in twenty-two, and mulberries in five. This certainly does not show great depredations upon fruit, even supposing that all the fruit was cultivated; but it is probable, especially in the case of blackberries, that much of it was wild.

Other vegetable substances were not eaten extensively, but appear to have been taken merely in default of something better. It is worthy of notice that the sumac seeds eaten are those of the harmless staghorn (*Rhus hirta*) and smooth sumac (*Rhus glabra*). Jays do not eat the seeds of poison ivy (*Rhus radicans*) or poison sumac (*Rhus vernix*), and in this respect differ greatly from the crow, the crow blackbird, and some of the woodpeckers. These last, and probably many other birds, feed largely upon sumac seeds during the winter, and thereby help to disseminate these disagreeable and harmful shrubs. It seems a little singular that a bird so fond of hard seeds as the jay should not avail itself of this food, which is always accessible in the colder months, but it is fortunate that it does not eat the seeds of the poisonous species. Remains of galls which grow on oak leaves were found in twelve stomachs, and possibly were eaten for the sake of the larvæ which they contained. Fragments of mushrooms were identified in seven stomachs, mostly taken in April and October.

EXPERIMENTS ON A BLUE JAY IN CAPTIVITY.

The examination of stomach contents was supplemented by experiments on a bird which had been in captivity but a few months and had no acquired tastes. In eating, this jay held its food on the perch usually with the right foot, but sometimes with both feet, and proceeded to tear it to pieces and devour it; hard substances, like kernels of corn and acorns, were repeatedly hammered with the beak after the manner of a woodpecker. It would eat dead mice to a certain extent, but did not appear to be extravagantly fond of them; it seldom or never ate a whole one, and seemed to prefer the brains to any other part. A live mouse was placed in the cage, but remained unmolested for two days. The jay was kept supplied with mocking-bird food, of which it ate freely, so that it was not hungry, and therefore selected only such other food as was appetizing. It ate most insects and preferred them to vegetable food. Its preferences were not strongly marked, although grasshoppers seemed to be the favorite insects, and black crickets were refused. Among beetles, Scarabæids were rather preferred to Carabids or Tenebrionids, but all were eaten. Chrysomelids were generally rejected, and the potato beetle (*Doryphora 10-lineata*) was always refused; the same was true of the elm leaf-beetle (*Galerucella luteola*), but one 12-spotted cucumber beetle (*Diabrotica 12-punctata*) was eaten. Click beetles (Elaterids and Tenebrionids) were apparently preferred to the long-horn beetles (Cerambycids).

On one occasion a basin of water was placed in the cage containing several Carabids (*Harpalus caliginosus* and *H. pennsylvanicus*), one Cerambycid (*Typocerus sinuatus*), one potato beetle (*Doryphora 10-lineata*), another Chrysomelid (*Chrysochrus auratus*), one black cricket, one large hairy caterpillar, and a large milleped (*Julus*). The milleped was taken first, the Carabids next, and finally all the insects were eaten except the Chrysomelids and the cricket.

Very large hard beetles, like *Alaus oculatus*, *Hydrophilus triangularis*, and *Passalus cornutus*, were not often touched, but in default of other insects were torn to pieces and the soft parts separated from the harder portions. Stink bugs (Pentatomids) seemed to be relished, but hairy caterpillars were only taken after most of the hair had been beaten off. Cocoons of a tussock moth were torn open to get the pupæ, and the large green warty caterpillars of the Ailanthus moth were eaten, but with no great relish. In several cases spiders were selected in preference to insects. Myriapods and earthworms were eaten less readily than sow bugs (*Oniscus*).

The bird would eat corn and sprouted acorns, but did not seem to care much for them. It ate apples, blackberries, and black raspberries, but rejected red raspberries, strawberries, mulberries, and elderberries; it swallowed the pulp of grapes only after removing the skin and seeds, and also ate a little peach pulp, but without great relish.

SUMMARY.

The most striking point in the study of the food of the blue jay is the discrepancy between the testimony of field observers concerning the bird's nest-robbing proclivities and the results of stomach examinations. The accusations of eating eggs and young birds are certainly not sustained, and it is futile to attempt to reconcile the conflicting statements on this point, which must be left until more accurate observations have been made. In destroying insects the jay undoubtedly does much good. Most of the predaceous beetles which it eats do not feed on other insects to any great extent. On the other hand, it destroys some grasshoppers and caterpillars and many noxious beetles, such as Scarabæids, click beetles (Elaterids), weevils (Curculionids), Buprestids, Chrysomelids, and Tenebrionids. The blue jay gathers its fruit from nature's orchard and vineyard, not from man's; corn is the only vegetable food for which the farmer suffers any loss, and here the damage is small. In fact, the examination of nearly 300 stomachs shows that the blue jay certainly does far more good than harm.

SEED PRODUCTION AND SEED SAVING.

By A. J. PIETERS,
Assistant Botanist, U. S. Department of Agriculture.

GENERAL REMARKS.

Man has so changed the form, habits, and properties of cultivated plants that in many instances their wild progenitors are unknown. But he has gone farther than this. By careful cultivation and selection he has so altered the nature of many cultivated plants that they exist no longer primarily for the perpetuation of the species, but for the good of man. The abnormally developed flowers, the succulent roots, the seedless fruits of our fields, gardens, and orchards, would not only be useless to a wild plant, but would be a positive hindrance to it in the struggle for existence. All the energies of the wild plant are bent to the production of seed. Annuals and biennials vegetate one or two seasons, produce seed, and die, while the longer-lived woody plants grow to maturity and year after year produce enormous numbers of seeds in order that a few may grow and perpetuate the species.

But the value of the seed lies not solely in the reproduction of its kind. There are many species, especially among cultivated plants, that are produced year after year without the agency of seed. A great part of the value of the seed lies in the fact that it is the product of a sexual union. Darwin and others have shown that the union of different individuals is advantageous to the species, and this union can occur only through the agency of the flower, and the effects of it can be propagated only by the seed. The union of different plants produces a progeny with greater tendency to variation than is possessed by the product of inbreeding. Among wild plants these variations enable a species to adapt itself to new conditions, thus extending its range and increasing its chances of living; in cultivated plants they form the basis upon which the plant breeder works for the improvement of old and the development of new varieties.

Moreover, nearly all our field and garden crops are propagated by seed, and the production of good seed is as essential to continued success in agriculture as good soil or careful cultivation. The production of seed therefore becomes at once a matter of the first importance as well to the originator of new varieties as to him who aims to keep some standard variety true and of the best quality.

HOW PLANTS PRODUCE SEED.

That the steps in the production of seed may be clearly understood, a brief description will be given of the parts of a flower and the growth of the seed both before and after fertilization. All seeds are produced by flowers. The flower usually contains two sets of organs, the sexual and the enveloping. Sometimes the latter are partially or wholly wanting, but the sexual organs—that is, the stamens and pistils—must be present either in the same or in different flowers in order that the plant may be fruitful.

The envelopes usually consist of two whorls of floral leaves, the outer or calyx (fig. 43, *a*), commonly green and more leafy than the inner whorl or corolla (fig. 43, *b*), which is often highly colored and of delicate texture. One or both of these whorls are found in nearly all flowers, and serve the double purpose of protecting the stamens and pistils while in the bud and, after opening, of attracting insects by their bright colors.

Frequently there is only one whorl, which is always the calyx; or both whorls may be absent, in which case the flower is said to be naked. The floral leaves forming the calyx are called sepals; those of the corolla are petals. The pistil or pistils, the female organs, occupy the center of the flower (fig. 43, *c;* fig. 44, *c*). They are commonly less numerous than the stamens, although this is often due to the union of several pistils into one, forming a compound pistil.

The pistil consists of the ovary at the base, the style, and the stigma at the end of the style (fig. 44, *e*, *f*, *g*). The stigma is the receptive surface on which the pollen falls, and is connected with the ovary by the style. In some flowers the style is suppressed or very short, while in others, as Indian corn, it is long and silky. The stamens, or male organs, are located between the pistil and the envelopes (fig. 43, *d;* fig. 44, *d*). They vary in number, but are commonly as numerous or twice as numerous as the sepals or petals. By suppression or multiplication these limits are frequently exceeded, and different species possess from one to an indefinite number of stamens. A stamen consists of a stalk, or filament, and an anther. The anther, which is commonly two-lobed, produces the pollen, the fertilizing element. The mass of pollen, as seen in an anther, consists of a countless number of pollen grains. These may be dry and dust-like, each grain being distinct from every other, or the grains may be sticky and adhere to each other in small, irregular, or sometimes regular, masses. When ripe, the anther opens and the pollen is exposed, to be carried away either by the wind or by insects and other animals.

In the majority of plants both sexes are present in the same flower. In a small number they are in different flowers, either on the same plant or on different plants. In the latter case the plants bearing only male flowers never produce fruit. For the production of seeds

a union of both sexes is necessary. This takes place when the pollen grains are deposited on the stigma of the pistil, and grow out into tubes which traverse the style and fertilize the ovules in the ovary (fig. 45). The ovule, the future seed, begins as an outgrowth within a cell of the ovary. As it grows, one or two coats are developed about it. The coats do not entirely surround the ovule, but leave a narrow opening, the foramen or micropyle, at one end. Through this opening the pollen tube finds its way to the embryo-sac of the ovule. After the union of one of the nuclei of the embryo-sac with that of the pollen tube the embryo begins to form. This is the future plantlet, and is the indispensable portion of every good seed.

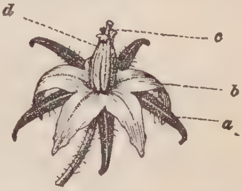

FIG. 43.—Tomato flower (*Lycopersicum esculentum*): *a*, calyx; *b*, corolla; *c*, pistil; *d*, stamens. The anthers are united about the pistil. (See fig. 44.)

After fertilization the ovary rapidly develops into the fruit (fig. 46). Often the calyx or some other part of the flower adjacent to the ovary becomes united to the latter and forms a portion of the fruit. In the seed the important changes are the growth of the embryo and of the endosperm, when present. The endosperm contains the food supply for the young plant. It is either absorbed by the growing embryo before the seed is ripe or remains as a distinct mass of reserve material outside of the embryo. In the latter case the seed is called albuminous; in the former, exalbuminous. In either case there is a supply of reserve material, consisting usually of starch, oil, or proteid, for the use of the embryo after germination. In exalbuminous seeds the reserve materials are stored in the cotyledons of the embryo, which often become very large and fill the seed, as in beans and peas (fig. 47). In albuminous seeds the embryo never entirely fills the seed, and it may be very small. Sometimes it is without differentiation of parts. In corn and wheat it lies outside of the albumen, which forms the bulk of the seed. The embryo and albumen are surrounded by a seed coat, which protects the delicate parts within, and in some seeds serves a useful purpose in germination (fig. 47, *a*).

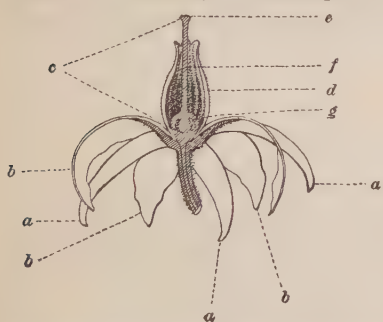

FIG. 44.—Tomato flower, longitudinal section: *a*, sepal; *b*, petal; *c*, pistil; *d*, stamens; *e*, stigma; *f*, style; *g*, ovary.

Three parts are readily distinguished in most embryos, viz, radicle, cotyledons, and plumule (fig. 47, *b*, *c*, *d*). The radicle becomes the primary root; the cotyledons or seed leaves either contain the reserve materials of the seed within themselves or they absorb the albumen after germination; the plumule becomes the stem of the plant.

CROSS AND SELF FERTILIZATION.

The matter of fertilization underlies the whole subject of seed production, for on the fertilization of the seed depends the purity as

well as the vigor of a variety. A flower is cross fertilized when its ovules are impregnated by the pollen of another flower; self-fertilized when they are impregnated by pollen from its own stamens.

The adaptations for cross fertilization are too numerous to be described in detail. Two great external agencies are concerned in the work, the wind and insects. The colors, odors, and irregular shapes of flowers and the secretion of honey are correlated with cross fertilization by insects. Insects visit flowers for the sweets they find, and are undoubtedly attracted by color and odor. While collecting the honey, insects are dusted with pollen, which, passing to other flowers, they deposit on their stigmas. Many flowers are so arranged that only bees and insects large enough to pollinate the flower can obtain the honey. This end is secured by the irregularity of the flower and in various other ways. Either the lips of the flower are so firmly closed that only a large insect can force them apart, or the throat is filled with hairs which effectually exclude unwelcome guests, or the honey is at the bottom of a long tube to which only the proboscis of a large moth or bee can reach.

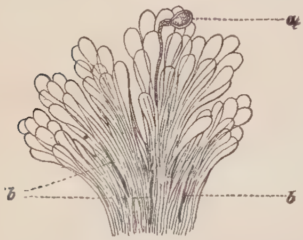

FIG. 45.—Section of a portion of the stigma of cucumber (*Cucumis sativus*), showing a germinating pollen grain: *a*, pollen grain and tube; *b*, portion of pollen tube cut off in the tissue of the stigma.

FIG. 46.—Pod of the common bean (*Phaseolus vulgaris*). This is the ripened pistil. The figure shows the seeds in position in the ovary.

The arrangements by which cross pollination is secured are principally of three kinds: (1) There may be some peculiarity in the structure of the flower that favors cross pollination and almost or quite prevents self pollination; (2) the sexes may be in different flowers; (3) the anthers and pistils of the same flower may mature at different times.

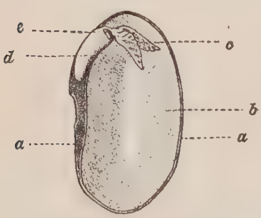

FIG. 47.—Seed of the bean (*Phaseolus vulgaris*). A dicotyledonous seed; one cotyledon removed to show the plumule: *a*, seed coat; *b*, cotyledon; *c*, plumule; *d*, radicle; *e*, scar left by the removal of the other cotyledon.

The peculiarities of structure are numerous and varied. A common type is found in the flower of the pea family; for instance, in that of red clover (*Trifolium pratense*). The flowers are visited by the bumblebee, whose long proboscis can reach down into the tube, at the bottom of which the honey is secreted (fig. 48). Smaller bees can not secure the honey, but they collect pollen and doubtless aid in fertilization while so

doing. The stigma stands out above the anthers, and a bee, thrusting his head into a flower, would first brush against the stigma, leaving some pollen from a flower previously visited, and then dust itself afresh with pollen, to be carried in turn to the next flower (fig. 48). Some farm operations depend upon these insect visits. Where mammoth clover is grown for seed, it is pastured or clipped in the early part of the season. This is done that the plants may not bloom before "bee time," for if they did there would be no seed. Bumblebees had to be imported into Australia before red-clover seed could be raised there. It is said that when insects are excluded not one-tenth of the flowers are fertile.

FIG. 48.—Bumblebee pollinating red clover. The bee is withdrawing its head from the flower where it has received the pollen at *c*: *a*, stamens and pistil of the flower; *b*, proboscis of the bee.

In the cabbage family arrangements are such that self-fertilization can take place if cross fertilization fails. In cabbage (*Brassica oleracea*) the honey is secreted at the bottom of the corolla tube. An insect sucking the honey would touch the stigma and the anther of one of the short stamens. At the next flower the pollen thus collected would most likely be deposited on the stigma. In case cross fertilization fails, the long stamens bend over and pollinate the stigma. That cross fertilization frequently occurs is proved, however, by the difficulty of keeping the varieties of cabbage, turnips, or other cruciferous vegetables from mixing.

FIG. 49.—Male flower of cucumber (*Cucumis sativus*). One petal cut away to show the stamens: *a*, sepals; *b*, petals; *c*, stamens.

The case in which cross fertilization is insured by having the sexes in different flowers is represented among our garden vegetables by the cucurbits. In pumpkins, squashes, cucumbers, and melons the male flowers appear first, followed by the female (figs. 49 and 50). Here cross fertilization is inevitable, and mixing invariably occurs when several varieties of a species are grown near one another.

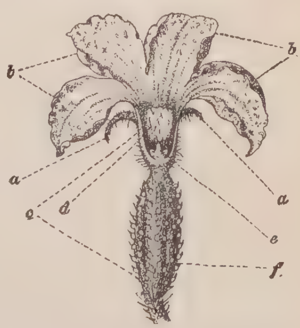

FIG. 50. Female flower of cucumber (*Cucumis sativus*). One petal cut away to show the stigma: *a*, sepal; *b*, petal; *c*, pistil; *d*, stigma; *e*, style; *f*, ovary.

The wind-fertilized flowers are represented among our common economic plants by the grasses and Indian corn. In these the flowers are simple, without odor, nectar, or conspicuous color, thus presenting no attraction to insects. The anthers

are borne on long, delicate filaments, which enable them to shake out their light and dry pollen with every breath of wind. Everyone has noticed how the pollen falls in showers from the tassels of Indian corn

Flowers in which the anthers mature before the pistil are common among our ornamental plants, the gentians, campanulas, and Clerodendron being conspicuous examples. In the plantains, which are among our greatest weed pests, the pistils mature before the anthers. In these the order of blossoming is from the base of the spike up, and in young spikes the stages of flowering can be traced on one spike; the younger flowers at the apex showing only pistils, the middle flowers old pistils and young anthers, the lower ones withered pistils and ripe anthers.

Cross fertilization may take place between flowers on the same plant or between flowers on different plants. In the latter case two distinct individuals enter into the union. They bring to this union those differences of constitution and habit which always exist between individuals, emphasized, perhaps, by differences in the conditions under which their ancestors have lived for one or more generations. In self-fertilization, on the other hand, there is the closest possible inbreeding. The conditions under which the sexual organs have matured are the same; they will therefore differ but little in their constitution. It would seem reasonable that seed produced by crossing different plants should give rise to progeny more vigorous and productive than that resulting from self-fertilization.

Darwin[1] proved by a long series of experiments that cross fertilization is beneficial, and that continued self-fertilization is injurious to the species. He crystallized his conclusions in the famous dictum, "Nature abhors perpetual self-fertilization."

In the course of his experiments, Darwin used many species from widely different orders, and in most cases several experiments were conducted with the same species. Many of the plants were grown for more than one generation from seeds produced by hand-pollinated flowers; in one case, that of the morning-glory (*Ipomœa purpurea*), for ten generations. Darwin found that, as a rule, the plants raised from seeds produced by cross fertilization exceeded in height, weight, and fertility those raised from seeds produced by self-fertilization. The same results were obtained by Bailey[2] in growing eggplants on a large scale. The cross-bred plants "were characterized throughout the season by great sturdiness and vigor of growth. They grew more erect and taller than other plants near by grown from commercial seed. They were the finest plants I had ever seen." The following summer 2,500 plants were grown from seed taken from this patch, and of these he says: "Again the plants were remarkably robust and healthy, with fine foliage, and they grew erect and tall—an indication of vigor."

[1] The Effects of Cross and Self Fertilization in the Vegetable Kingdom.

[2] L. H. Bailey, Plant Breeding.

The degree of relationship of the plants used in the cross has much to do with the benefit derived. Crosses between plants grown for generations under the same conditions tend to approximate the results of self-fertilization. But the introduction of fresh stock—that is, of plants grown under other conditions of soil, moisture, climate, or care—puts new vigor into the cross. In Darwin's experiments plants of morning-glory that had been intercrossed for nine generations were crossed with fresh stock and compared with plants intercrossed for ten generations. They exceeded the latter in height as 100 exceeds 78. Cabbages were compared by weight, and the plants resulting from a cross with fresh stock upon the second intercrossed generation were to the third intercrossed generation as 100 to 22. More examples might be given, but these are enough to show the immense advantage of introducing fresh stock.

As has already been said, the purity as well as the vigor of a variety depends upon the fertilization of the seed. While cross fertilization has been clearly shown to be productive of more vigorous plants and therefore a benefit so far as the life of the species is concerned, there are other matters of vital importance to the farmer. The first of these is the purity of the variety. The seed must be genuine, that is, it must reproduce the variety from which it purports to come. No matter how well the seed germinates nor how vigorous the plants, if they are not of the variety wanted the crop is at best a partial failure. While crossing between plants of the same variety is beneficial, the more so if their ancestors were not grown under the same conditions, crossing between varieties of a species should, as a rule, be guarded against. Intelligent crossing of varieties, or of species even, may lead to good results, but indiscriminate crossing can only result in the loss of well-established types.

The varieties of most of our common garden plants cross readily. The great pea and bean growers are careful not to grow two varieties of either near each other. Some insist upon but one variety being grown on the same farm, while others permit more than one on a farm, but specify the distance they shall stand apart, from 10 to 40 rods being usually required.

In the cabbage family, to which many of our vegetables belong, cross fertilization is not uncommon. The varieties of cabbage, kale, cauliflower, brussels sprouts, and kohl-rabi all belong to one species (*Brassica oleracea*) and cross freely. To raise any variety for seed, it must be grown in large patches, away from any variety with which it will cross. Where only a few plants produce seed, there is every chance that bees may bring pollen of another variety and the plants raised from that seed not be true to name. The varieties of corn cross readily and can not be grown near each other without danger of mixing. This may occur even when the varieties are considerable distances apart. We learn from a seedsman of high standing that in

his experience corn in one field has become mixed with that in another 6 miles distant. In his opinion crows that fed on both fields carried the pollen. Frequently the effects of the cross are visible the same season in colored grains. When this occurs, the mixing is easily detected and the corn can be discarded, but often there is no such indication, and a mongrel variety the following summer is the first indication the farmer has that his seed corn was not genuine.

Pumpkins, squashes, melons, and cucumbers are fertilized by insects, and when different varieties of the same species are grown near each other pure seed is out of the question. Even when the varieties are grown some distance apart there is still danger of mixing. A seedsman states that he has known watermelons to cross when grown a mile apart. Bees carry pollen long distances, and in flying from one field to another are likely to leave foreign pollen on the stigmas of the flowers they visit. Experience has shown that tomatoes will cross in the field. Six varieties were grown on the Cornell Experimental Grounds,[1] and from the seed saved eighty-seven plants were grown, six of which were evidently crosses. It is evident, then, that garden seeds grown on a small scale are extremely likely to mix when two or more varieties of the same plant are grown together.

HOME GROWING OF SEED.

In former years home seed saving was extensively practiced. Nearly all market gardeners and those who supplied their own tables saved the seed of their best plants. The seed business was then but little developed, and dealers were not so well prepared to supply the demands of an exacting public. But even as early as 1796 Marshall, in his book on gardening, advised against saving seed at home and urged that those whose business it was to grow seed could do so more cheaply than it could be done at home. Other writers on horticultural matters took different views, some even advising the gardener to save seed of all the varieties he raised.

The objections to growing one's own seed are in general that it can not be as well done, or, if as well, not as cheaply, by the general farmer or gardener as by the professional seedsman. These objections have greater force to-day than they had in the time of Marshall. Reliable dealers and growers have accumulated such a wealth of experience and exercise such care that although nongenuine seed may sometimes be sold by an honest firm it is done through ignorance rather than intent, and is an exceptional occurrence.

Home seed saving is most likely to be profitable upon the farm where plenty of land is available. When space is limited, it is too valuable to be used for home seed raising unless the grower has some choice strain which he fears can not be obtained pure from seedsmen. Where land is plenty and the additional labor is the only outlay, home

[1] Bulletin No. 32, Cornell University Station.

seed saving may be successfully practiced. With proper care most garden and flower seeds can be saved, as well as field seeds and potatoes. The danger to be avoided in seed raising comes principally under two heads—mixing of varieties and deterioration.

HOW SUCCESSFULLY CONDUCTED.

If more than one variety of a species is grown on the same farm it will be difficult to keep them pure. The difficulty may be overcome in a measure by separating the plants grown from seed as far as possible. But, as is shown elsewhere, natural crossing can not always be avoided within the limits of a farm. A more certain method is to grow seed of but one variety in any year. By growing them in rotation two or three related varieties may be maintained on one farm without mixing.

As a rule, seed more than one year old will not have as good germinating power as fresh seed, but with proper care in harvesting and storing most seeds will retain a sufficient vitality to be used after two or three years. It is, however, not advisable to use old seed, except when necessary. In most cases one variety of a kind will be sufficient for the ordinary kitchen garden, and where this is true the multiplication of varieties should be avoided.

Deterioration of varieties can be prevented by constant care in selecting the seed-bearing plants. Only the best plants should be selected, and these should be raised for seed only. Too much stress can not be placed upon the folly of leaving some of the poorest plants for seed because they can not be used for anything else.

Seed peas and beans should be saved from the best plants, selected for the purpose, and not from those from which a crop has been gathered. Radishes, turnips, and beets that are not good enough for table use are also unfit for producing seed. Cabbage seed grown from the stump after the head has been marketed is certain to be inferior and to give poorer plants the next season than seed saved from the soundest and best heads.

In selecting the plants the grower will of course be guided by the purpose in view. If he wishes early peas, he will select the plants that yield the earliest pods; if a sound head of cabbage is wanted rather than earliness, plants having this quality best developed will be selected for seed. In every case plants showing the desired qualities to greatest perfection should be set apart. In this way a variety will not only be kept up, but may even be improved. Seedsmen maintain the type of a variety by a rigid "rogueing" of their fields, that is, destroying all plants not conforming to the type. Some varieties would "run out" in a few years if this were not practiced.

Another source of deterioration is inbreeding. Where the same stock is raised year after year on the same place, it is almost sure to suffer a loss of vigor if not of quality. Usually this may be remedied by the occasional introduction of fresh stock. Even if the seed was

grown on a neighboring farm, the conditions would be slightly different and the plants would be of different ancestry. The plants from this seed grown beside those from the home stock would cross with the latter, and the result would be increased vigor and productiveness without any injury to the variety.

Only second in importance to the selection of the plants is the selection of the seed itself. Not all the seed even of a good plant should be used for reproduction. Of the seeds gathered from prime plants some will be better than others. Only the largest, plumpest seeds should be preserved. It is true that large seeds from poor plants may be worse than small seeds from good plants, but the best is never too good. By saving only the largest seeds from the most nearly typical plants the stock can not fail to be improved year after year. Too much emphasis can not be placed upon this matter of selection. The selection of the best seed from typical plants is as essential to continued success in agriculture as are good soil and careful cultivation.

If a farmer is unwilling to exercise care in the production of seed, he would do much better not to attempt it. It takes years to build up a good variety, but a few seasons of carelessness in saving seed will suffice to destroy it. If he will not or can not exercise care in selection and in preventing undesirable crosses, the farmer would do much better to purchase seed each year. He may occasionally get a poor lot of seed, but if he buys from reliable dealers success will be far more frequent than failure.

HARVESTING AND STORING.

Seed should be allowed to ripen on the plant when possible, but must be gathered before the pods burst. Where there are but a few pods, they can of course be picked by hand when the seeds are fully matured. Seedsmen find it necessary to harvest the crop a little before full maturity, in order to prevent loss of seed. Melon and other wet seeds should be carefully spread out to dry, after which they can be safely kept for several years. When the seed on a plant ripens unevenly, the stalk may be cut and set away in a dry shady place to mature. The immature seeds, if not too young, will ripen and be of good quality.

When the seeds have been cleaned, they should be kept in a dry place. Seeds can safely endure natural extremes of heat and cold if kept dry. The way seeds are stored materially affects the length of time they will remain good. Seeds carefully grown, selected, and stored will repay all the attention bestowed upon them. A good farmer gives constant attention to selection and care in his treatment of live stock, corn, wheat, and potatoes, but too few give to their vegetable gardens the attention that they deserve. Greater care in selecting or purchasing seed would go far toward improving the condition of the farm garden and making it provide an unfailing supply of choice vegetables for the home table.

INSECT CONTROL IN CALIFORNIA.

By C. L. Marlatt,
First Assistant Entomologist, U. S. Department of Agriculture.

GENERAL REMARKS.

The semitropical climate and other favoring conditions of much of California have made this region the great fruit center of America. Serious drawbacks to horticulture, however, have not been entirely wanting, and, in fact, the very conditions which make the growth of a great variety of fruits possible prove most favorable also for the presence and multiplication of many grievous insect enemies. These were early introduced on plants received from all quarters of the world, and the problem of insect control had, therefore, to be promptly met. It was taken hold of with such intelligence and vigor both by individuals and by the State authorities, and the outcome has been so successful, that the present system of control in California furnishes one of the best practical guides for similar efforts elsewhere.

The following paragraphs summarize impressions gained during a four weeks' study, in October and November, 1896, of horticultural entomology in California, particular attention being given to the scale insects of citrus and other fruits, and the results of the importation from Australia and New Zealand of certain parasites and predaceous enemies of these scale insects.

CULTURAL AND CLIMATIC CONDITIONS.

The visitor from the East is first impressed with the distinctive cultural conditions in California and the important bearing these have on insect control. The necessity of irrigation for almost all fruits, including all citrus trees, limits cultivation to comparatively well-defined tracts and greatly facilitates the thorough inspection of orchards. The greater value of the products makes possible also a much greater annual outlay in care of land and expenditures for the proper maintenance of healthy conditions of trees and measures looking to the prevention of inroads of injurious insects. The growing of fruits is commonly also the only industry of importance, and therefore there is no division of interests. All this contrasts markedly with the conditions obtaining in the East, where fruits are grown by nearly every farmer and usually as a mere accessory to the regular farm crops, under such conditions as to make it often impracticable

to undertake expensive remedial measures, and over such wide areas and often in such out-of-the-way places that inspection and control are rendered almost impossible, at least with the thoroughness and care practiced on the Pacific Coast.

Other influences which have an important bearing on the relation of insects to fruits in California are the climatic conditions, particularly the summer heat and the long summer drought. Heat is a most important factor, and it has been repeatedly demonstrated that where the temperature remains, as it often does, at 106° F., or above, for two or three days at least two-thirds of the black scale are killed. As an illustration of this, it may be stated that during the summer of 1896, when the drought was unusually severe and the temperature correspondingly excessive, it was the experience at Riverside that at least 90 per cent of the black scale was destroyed by heat, including even eggs beneath the parent scales. The benefit from this source obtains in greater or less degree in the case of all the important scale insects of both citrus and deciduous trees, and is a means of protection which is rarely, if ever, experienced in cooler or moister climates; in fact, it does not hold in northern California, where the rainfall is greater and the summer temperature less severe. The destruction of scale insects from this cause may be facilitated by the system of pruning which opens up the tree by the removal of interior growth, and such pruning is practiced and recommended by many growers in southern California.

When considered, however, in connection with the imported ladybird enemies of scale insects, which will be later discussed, the dry heat and pruning are both inimical. These introduced parasites need a certain amount of moisture for successful multiplication, hence their usefulness is most marked in the moister coast region, and advocates of reliance on parasites discourage pruning, since a dense interior of citrus and other trees furnishes the needed shade and moisture, and also protects from bird and other enemies. The need of such protection is illustrated about San Francisco and northward, where the imported ladybirds are less successful on account of lack of shelter afforded by deciduous trees, particularly in winter.

SYSTEM OF INSPECTION AND QUARANTINING.

Perhaps the most important element in the management of injurious insects in California is the present system of official inspection and control, which is the outgrowth of many earlier experiments in this direction. Without going into details or alluding to the very important supervisory work of the State board of horticulture, attention will be drawn merely to the county system of inspection. Each county has or may have, on petition of fruit growers, county horticultural commissioners, who are practically official entomologists and have charge of all matters relating to injurious insects, both as to quarantining against their introduction on plants and their eradication.

These commissioners either do their own inspecting or are empowered to employ local inspectors, who may number from one to twenty-five or thirty, according to the number of districts into which the county may be divided. The local inspectors are supposed to be familiar with the common scale insects and experienced in the application of remedies, and they make, at sufficiently frequent intervals, what is practically a tree-to-tree inspection, and are empowered to enter all premises and enforce action. The result is that the presence of injurious scale or other insects is commonly detected at the very outset and remedial measures are promptly instituted. An entirely different state of affairs from what we are familiar with in the East is thus brought about. Instead of neglect until a serious stage is reached, perhaps beyond repair, the insect rarely gets a foothold and is stamped out before any real injury results. Work is therefore, in the main, not remedial, but preventive, and in going through the orchards of citrus or other fruits in California one is usually impressed with the almost complete freedom from injurious insects, and, from an Eastern standpoint, treatment of any sort would be often deemed entirely unnecessary. Here, however, if a few scale be discovered, the trees are promptly treated, often in an expensive way, the owners and all interested fully appreciating the fact that it is much better to prevent the increase of noxious insects at considerable cost, if necessary, while the plant is still in flourishing and vigorous condition rather than to wait until it is weakened and the possibility of its response to treatment is rendered doubtful. One witnesses, therefore, fumigating or spraying operations where scarcely a scale is to be seen, and it is by this constant and minute inspection and promptness in treatment that the excellent condition of the orchards is maintained. Remedial work is often done under the supervision of experts detailed by the county commissioners and frequently under contract by persons who make a business of it, the charge being either so much per tree, as with treatment with gas, or so much per gallon, with washes. The conditions outlined apply with especial force to the citrus districts of southern California.

In addition to this very careful supervision of existing plantings is the strict enforcement of quarantine regulations as a safeguard against the importation of new insect enemies to fruits. Very careful regulations on this subject have been enacted, the latest dated August 15, 1894. These regulations prevent the debarkation at any point in the State of California of living plants or fruits until they have been carefully inspected by quarantine officers, and, if necessary, properly fumigated. In the case of badly infested stock or wherever insects or diseases new to the State are found the material is destroyed outright. The quarantine regulations apply to all material brought in from Central or South America or other foreign countries on steam or sailing vessels, the ships being visited by a quarantine officer at the

moment of their arrival in port, and also cover the introduction of plants from other States or adjacent countries on the lines of railroads entering California. The Southern Pacific Company and Wells, Fargo & Co. notify the State quarantine officer of the arrival of trees and plants at their different stations, and instruct their agents not to deliver the material to the consignees until it has been properly inspected. This inspection is carried on by a chief quarantine officer at San Francisco and by the local authorities in the different counties. The amount of infested material which is by this system intercepted from year to year is enormous, and shows how readily and constantly insect pests and plant diseases may be introduced with living plants where no preventive measures are taken. At the port of San Francisco alone, during the year 1893, 156 steamers and sailing vessels from foreign countries had on their manifests, in possession either of the passengers or crew, plants or trees. This was out of a total of 400 vessels inspected. The great bulk of these plants came from Japan, but nearly all the transpacific countries were represented, as well as South and Central America and Mexico. Very many of these plants were infested with injurious insects already present in California, but frequently with species not hitherto known in the State.

In connection with the inspection for insects, other dangers are also averted. No less than five flying foxes were intercepted on shipboard and killed. This bat, or vampire, is a great menace to fruit interests in Australia, and would have like dangers for California.

THE WORST SCALE INSECTS OF CALIFORNIA.

The most destructive insect enemies of fruits in California are undoubtedly the scale insects, few if any other insects, aside from the grape Phylloxera, at all approaching them in this respect. Of these, the ones of greatest moment, and in the control of which vast sums of money are expended, are the black scale, the red scale, and the San Jose scale. For the olive and the citrus plants the black scale is the most important, and for the deciduous plants the San Jose scale takes similar rank.

Of the three scale insects mentioned, the most serious pest at the present time in California is undoubtedly the black scale (*Lecanium oleæ*), which occurs practically all over the State, and, in fact, has a world-wide distribution. This insect is not only a heavy drain on the vigor of the trees, but exudes a great quantity of honey dew, in which a fungus propagates, creating a black stifling deposit which adheres closely to the twigs and leaves and discolors the fruit. This scale infests both citrus and deciduous trees, but is particularly injurious to the former and also to the olive. It is practically limited, so far as severe injuries from it result, to the moist coast regions. The mountain districts remote from the coast have hitherto seemed unfavorable to it, although it is now slowly extending its range into these districts

and is there becoming gradually acclimatized. The mature scale or the eggs beneath the old scale can not be killed with the gas treatment or any other practicable method so far discovered, and hence it must be proceeded against in its immature stages. In the lower portions of the State, from Los Angeles southward, the hatching of this scale, which is single brooded, is comparatively uniform and is usually almost altogether completed by the end of October, when treatment either with gas or washes will be effective. In the coast district about Santa Barbara the period of hatching is much prolonged, extending from September well into November or December. At the time of the writer's visit, early in November, scales in all conditions were found on trees at Santa Barbara, many with unhatched eggs, and about San Francisco hatching had hardly begun. Where such irregularity occurs, the difficulty and expense of treatment are greatly increased, on account of the necessity of repeating the applications several times.

The red scale (*Aspidiotus aurantii*) is a distinctive enemy of citrus trees, and, in common with the black scale, is much more injurious near the coast, doing most damage in the old seedling orchards in the vicinity of Los Angeles. Still, in many of the best citrus districts, including Riverside, Redlands, Pomona, Ontario, etc., this scale is not at all bad and has never caused much loss, largely from the fact that treatment has always been instituted so promptly that the scale has never gained a real foothold. It seems, however, as with the black scale, to be slowly extending its range and adapting itself to the upland climate. In common with the San Jose scale, the red scale is subject at times to the attacks of a contagious disease or fungus, which affects both young and mature scales. This has been especially noticed in the district south of Los Angeles.

The third important scale in California is the San Jose scale (*Aspidiotus perniciosus*). This enemy of deciduous fruits, nearly all of which it attacks, is much less injurious now than in its earlier history, especially in the Santa Clara Valley, which includes the San Jose district, and in southern California. The statements which have been made, however, that it is no longer injurious in California are quite erroneous. The conditions of climate, already referred to, sometimes kill it out, and often it seems to be destroyed by a fungous disease, but in the very districts where these influences are most active orchards neglected or improperly sprayed exhibit trees in as bad condition as can be found in any of the orchards of New Jersey or Maryland. The action of its two most active enemies, *Chilocorus bivulnerus* and *Aphelinus fuscipennis*, breeding, as they do, the year round almost, is undoubtedly greater than in the East, where their usefulness is limited to but little more than half the year. The standard remedy for this scale in California, viz, the lime, salt, and sulphur wash, is undoubtedly thoroughly effective, and it is the

constant and thorough treatment with this wash that in the main keeps the orchards in their present satisfactory condition.

Many other scale insects in California are important at times, but much less so than the three mentioned above.

The white scale (*Icerya purchasi*), which, before the introduction of its imported ladybird enemy (*Vedalia cardinalis*) (fig. 51), threatened the very existence of citrus cultures in California, is now no longer an important injurious insect. Very rarely are colonies of it found, and usually scattered specimens only can be seen. In southern California important scale insects new to the State have been recently introduced, such as the long scale (*Mytilaspis gloverii*) and the purple scale (*M. citricola*). These serious enemies of citrus trees were introduced about 1889 or 1890 with two car loads of citrus trees from Florida, which were planted without inspection in the Rivera and San Diego Bay districts. With the same lot of trees came also the rust mite (*Phytoptus oleivorus*), which has gained a foothold in the important lemon districts about San Diego. In Florida this mite is not now considered especially objectionable, rusty oranges often commanding better prices than bright ones, on account of their being sweeter and otherwise preferable. In the case of the lemon, however, an injury to the rind is an important consideration, a perfect rind being absolutely essential to the lemon on account of the valuable products obtained from this portion of the fruit and the uses to which it is put. Extended reference will not be made here to other important insects, such as the clover mite (*Bryobia pratensis*), locally known as the red spider; the peach-tree borer (*Sannina pacifica*); the peach-twig borer (*Anarsia lineatella*); the grape root-louse (*Phylloxera vastatrix*), etc.

FIG. 51. *Vedalia cardinalis* (the imported ladybird enemy of the white scale): *a*, ladybird larvæ feeding on female scale; *b*, pupa, and *c*, adult ladybird; *d*, orange twig showing scale and ladybird's natural size (original).

THE IMPORTED PARASITIC AND PREDACEOUS ENEMIES OF SCALE INSECTS.

In no country in the world has the possibility of control of insects by introducing and fostering their natural enemies been so thoroughly tested as in California. The very notable instance of the entire eradication of the white scale by the introduction from Australia of its ladybird enemy, *Vedalia cardinalis*, demonstrated the possibilities in

this direction in the most striking way. This one experiment saved the State its citrus industry, or the equivalent of many millions of dollars, and gave the greatest confidence in many quarters in this means of controlling insects, as well as incited the later action looking to the introduction of beneficial insects on a much larger scale. By legislative enactment, approved March 31, 1891, $5,000 was appropriated by the State of California "for the purpose of sending an expert to Australia, New Zealand, and adjacent countries to collect and import into this State parasitic and predaceous insects." With the consent of the honorable Secretary of Agriculture, Mr. Albert Koebele, a field agent of the Division of Entomology, stationed at Alameda, Cal., who had previously been instrumental in introducing *Vedalia cardinalis*, was detailed for the work, the expenses of the trip being borne by the State of California. His chief object was to obtain predaceous insects which might exterminate the black scale, the red scale, and the San Jose scale. Mr. Koebele's mission lasted upward of a year, and during this time he imported into California probably 60,000 specimens, representing very many species, chiefly of ladybirds. Five or six of these species took hold well from the start, and two or three of them are still represented abundantly in the orchards of California, the others having practically disappeared. The important ones remaining include a very efficient predaceous enemy of the black scale in the little *Rhizobius ventralis* (fig. 52), and two much smaller species, *R. debilis* and *R. toowoombæ*, which attack the black scale, and also the red scale and San Jose scale to a less extent. The latter of the smaller species (*R. toowoombæ-lophantæ*) had already been accidentally introduced into California prior to Mr. Koebele's last trip, and is much the more abundant and widely distributed of the two.

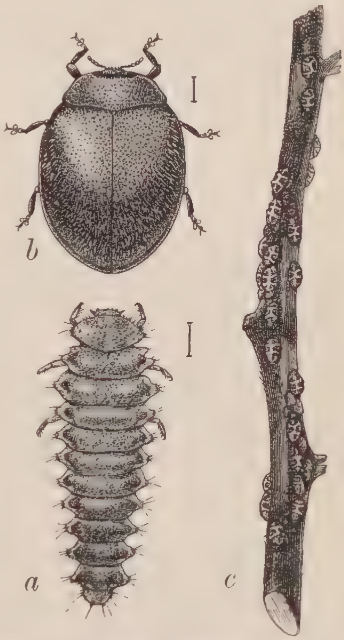

FIG. 52.—*Rhizobius ventralis* (the imported ladybird enemy of the black scale): *a*, larva, and *b*, beetle, both greatly enlarged; *c*, twig of orange with black scale, natural size (original).

Two other species which obtained a foothold at the start and gave great promise are *Orcus chalybeus* and *O. australasiæ*. The former was liberated in an orchard near Los Angeles and multiplied considerably for a time, but disappeared almost entirely during the winter of 1895–96. Both of these species obtained a good foothold on the

ranch of Hon. Ellwood Cooper, near Santa Barbara, and up to the winter mentioned were very abundant, particularly the *O. australasiæ*, which at one time, on the authority of Mr. Cooper, could be taken by the handful where it had collected together, as does the common ladybird, for hibernation. It has now, however, practically disappeared. The disappearance of these two species seems due partly to climatic conditions and, in the case of Mr. Cooper's ranch, to the almost complete exhaustion of the black scale, which furnished their principal food supply. The two species, therefore, now of particular importance are *Rhizobius ventralis* and *R. toowoombæ*. The closely allied and rarer *R. debilis* can be distinguished from the latter with difficulty.

Rhizobius ventralis was early colonized on the Cooper ranch, and during the last three years has been distributed in enormous numbers to different parts of the State, 300,000 or 400,000 having been colonized in southern California alone. This beetle is by far the most useful of the recent importations by Mr. Koebele, and has already done much good. It is about one-eighth of an inch long, oval, and in color nearly black, but clothed with whitish hairs, which give it a grayish appearance. A few pairs were received by Mr. Cooper in May, 1892, and by October of the following year they had so multiplied that 453 colonies had been distributed and the black scale was stamped out in the olive orchard where they had been originally liberated. The larvæ of this insect are found throughout the winter, and it practically breeds the year round in southern California. Colonies are easily sent out by inclosing them in wooden boxes with some dampened sphagnum moss.

Many fruit growers are discouraged and resume spraying because the scale is not immediately exterminated by the ladybirds, forgetting that at least a year or eighteen months is necessary for the introduced ladybirds to become numerous enough to be effective, and a year or two more, perhaps, to exterminate the scale. This insect requires favorable conditions of moisture and winter protection and dense foliage to maintain it successfully, and considerable care has to be exercised to effect its colonization. It often happens that colonies of several thousand liberated together will entirely fail, and at other times a few hundred or a much smaller number will take hold and multiply enormously. One great difficulty in the introduction of colonies of ladybirds is the fact that they are preyed upon by the little lizards, which are very abundant, and also by birds.

In notable instances this ladybird has effected the entire eradication of the black scale in badly infested orchards. This is particularly true of the Cooper ranch and in the coast regions of southern California, where the conditions are most favorable. In the more elevated and dryer fruit districts of southern California, and in northern California on deciduous trees, it is not very successful against the black

scale, and in the latter situation fails to winter well on account of the lack of protection furnished by deciduous trees. It is an active enemy of all the Lecanium scales, and will also feed on plant lice.

The best results with these imported ladybirds are exhibited on the ranch of Hon. Ellwood Cooper, president of the State board of horticulture, and so fully convinced is Mr. Cooper of the efficiency of these natural enemies that he has abandoned all other means of control. Mr. Cooper's ranch, which is a very extensive one, has large orchards of olives, with smaller lemon and orange orchards and tracts planted to figs and persimmons, together with nut-bearing trees, etc.

Before this last importation of ladybirds was made Mr. Cooper's olives, persimmons, lemons, etc., were badly infested with the black scale, the trees being much blackened with the associated fungus, and the fruit products inferior and limited in consequence. About three years ago Mr. Cooper discontinued the application of washes to his trees and put entire reliance on the imported ladybirds to control the black scale. Mr. Cooper's ranch at the present time is practically free from the black scale, and his trees are bright and clean in appearance. He ascribes all of this benefit to the ladybirds, particularly *Rhizobius ventralis*, with some assistance from the smaller Rhizobiids and the two species of Orcus already mentioned. Probably all these ladybirds still occur on his ranch, the Rhizobiids, at least, being present in some numbers. The black scale still occurs scatteringly on his ranch, or, as he expresses it, "barely enough for seed." In fact, it is not expected that these ladybird enemies will effect the complete destruction of scale insects, nor would this be in accordance with nature, but their champions hold that they will keep these enemies of fruit trees in such check that no important damage will result. Rather than have the scales and their ladybird enemies with them entirely disappear, Mr. Cooper is contemplating colonizing the scale in isolated groves as ladybird farms, so as to have material in readiness in case of need for general dissemination throughout his orchards.

Mr. Cooper seems to have demonstrated and, he says, has thoroughly convinced himself that spraying and gassing can not be used in conjunction with these natural enemies. All of these treatments are very prejudicial to the successful multiplication of the ladybirds, and so fully convinced is he of this that he refuses to send out colonies of ladybirds to anyone who sprays or otherwise treats his trees. He goes so far, in fact, as to hold that to spray where ladybirds have been liberated should be made a criminal offense, with a severe penalty attached. His own experience is certainly very instructive, and seems to bear out his conclusions. Spraying had been constantly practiced on this ranch prior to the introduction of ladybirds, and was continued some time after they had been introduced. In one instance some forty-nine trees in the center of an olive orchard

were left unsprayed, the surrounding trees being treated with kerosene emulsion. *Rhizobius ventralis* was introduced about the same time or soon after. Immediate benefit was noticed in the greater vigor and healthier color of the sprayed area, contrasting with the blackened or sooty appearance of the unsprayed portion. The ladybirds, however, worked altogether on the trees which had not been sprayed, and refused to take hold at all elsewhere. As a result, nine months or a year afterwards, the condition of things was reversed, the sprayed trees were again black and sooty, and the unsprayed trees were freed of the scale by the Rhizobiids, and were of a healthy bright color. The difference in the appearance of the two portions of the grove was noticeable at a distance and remained so for some time afterwards, and convinced Mr. Cooper that the presence of the wash on the trees was sufficiently distasteful to the Rhizobiids to deter them from working in the sprayed portion of the grove for a long period. He holds, therefore, that the failure of the Rhizobiids to take hold effectively in many places is due to the fact that the owners of these ranches continue spraying. Mr. Cooper's experience has been so successful that he is convinced that all injurious insects can be controlled by the introduction of the proper natural enemies, with the resulting saving of the amount now spent in washes, etc., which, in his case, was four or five thousand dollars yearly.

That in some measure the disappearance of the black scale on Mr. Cooper's ranch is due to the effect of climate or disease is a fair inference, in view of the experience elsewhere; but the condition of his grove, as contrasted with other groves at Santa Barbara, seems to warrant the giving of much credit to the ladybirds. It will take, however, an experience of some years to demonstrate whether the scales, which are now nearly exterminated, will be kept by these ladybirds from reappearing in destructive numbers, and, if they do reappear, whether the ladybirds will again bring them under subjection.

Of the other insects imported by Mr. Koebele, two are worthy of mention. One of these, *Cryptolæmus montrouzieri*, is an important enemy of several Coccidæ, such as the mealy bug, Pulvinaria, etc. This is the species which was introduced in Hawaii, and has been so successful there in ridding coffee plantations of *Pulvinaria psidii*. It is being reared in confinement and distributed in portions of southern California, where the mealy bug is an important pest, and specimens brought to Washington have demonstrated their usefulness by cleaning orange trees in the hothouses of the Department of Agriculture of mealy bugs. It gives promise of being a valuable outdoor enemy wherever the climate is favorable, and in the North and East will be a valuable indoor means of controlling soft scales. The other ladybird referred to is *Novius koebelei* Oll., which preys upon several injurious scales, and is quite as important an enemy of the white scale as *Vedalia cardinalis*.

The benefit from native parasitic insects was also very noticeable, particularly the parasitism of the brown apricot scale (*Lecanium armeniacum* Craw) by *Comys fusca*, in the Santa Clara Valley, frequently amounting to the parasitism of from 75 per cent to 90 per cent of the scales. The San Jose scale is also very abundantly parasitized by the *Aphelinus fuscipennis*. Of the native ladybirds the most efficient is the common twice-stabbed species, *Chilocorus bivulnerus*, which, as an enemy of the San Jose scale, is much more important than any of the imported species and is also a general scale feeder, and occurs abundantly in orchards throughout the State.

CONTROL OF INSECTS BY THE USE OF WASHES AND BY FUMIGATION.

Much of the work with insecticides in California has been similar to that done elsewhere, yet the two or three most effective means of destroying insects originated in California and are still peculiar to the Pacific Slope. Important among these are the gas treatment, the resin washes, and the lime, sulphur, and salt wash.

It may be stated of all the washes or other methods, that the complete destruction of the scale is rarely if ever secured by their use, and is not, indeed, hoped for. Experience has shown that the best that can be done is to effect a practical elimination of the scale for the time being, and it is often necessary to repeat the treatment every year or two. In exceptional cases it may not be necessary to do this more than once in three years. All applications are therefore recognized to be as necessary and continuous a charge on the crop as is cultivation or irrigation.

THE GAS PROCESS.

The use of hydrocyanic acid gas originated in California, and was perfected by a long period of experimentation by an agent of this division, Mr. D. W. Coquillett. It has not been followed to any extent elsewhere, however; but in southern California it is held to be the best treatment for citrus trees and is now better understood and more satisfactory than ever before. It is especially applicable to citrus trees, the abundance of foliage and nature of the growth of which enables comparatively heavy tents to be thrown over them rapidly without danger of breaking the limbs. With deciduous trees it has not been practicable to use tents to any extent, except in the case of nursery stock, which may be brought together compactly and treated in mass under tents. This gas is also the principal agency used in disinfecting material coming into California from abroad.

The practice of "gassing" or "fumigating," as it is called, differs very little from the method employed a number of years ago when the process was first perfected, the main difference being in the fact that refined cyanide (98 per cent) is generally used in preference to the fused 58 per cent grade hitherto employed. The latter gives good

results when it is uniform, but, unfortunately, this is rarely the case, and even in different parts of the same barrel great variation often occurs. Only about two-thirds as much of the stronger cyanide is used as of the weaker grade. The following table, prepared by Mr. John Scott, horticultural commissioner of Los Angeles County, gives the proportion with the stronger cyanide for trees of different sizes:

Height of tree (feet).	Diameter through foliage (feet).	Water (fluid ounces).	Sulphuric acid (fluid ounces).	Cyanide potassium (ounces).
6	4	1	½	½
8	6	2½	1¼	1¼
10	8	3½	2	2
12	10	6	3	3
12	14	9	4½	4½
14	14	10	5	5
16	16	12	5½	5½
18	16	12	6	6
20	16	13	6½	6½
22	18	15	7¼	7¼
24	20	16	8	8
26	20	16½	8¼	8¼
30	20	17½	8½	8½

The old statement that less time is required for small trees or plants than for larger ones is found to be an error, and, in fact, it is reasonable that an insect is no more easily killed on a small plant than on a large one. The limit in application of gas is to apply it at a strength and for a length of time, forty to forty-five minutes, as great as the tree can stand, and, in fact, the tender terminals of the tree should be slightly scalded, which is proof that the gas is of proper strength, and treatment of this character is necessary to destroy the red scale and the young of the black scale. For very compact trees with dense foliage from one-fourth to one-third more gas should be generated, and this is true also of the moister coast regions, or within 10 miles of the coast, the moisture or the cold surface of the leaves condensing a certain proportion of the gas. In the case of young trees and nursery stock there is much less danger of scalding if the gas be generated slowly, either by employing a greater amount of water or using the cyanide in large lumps.

Trees are fumigated for the black scale in southern California in October, or preferably in November, the young black scales in this part of the State having usually all emerged by October 1. After the black scale has abandoned the leaves and gone back to the twigs and fixed itself firmly, the gas is no longer effective against it. The red scale may be treated with gas at any time, but preferably at the season already alluded to. The applications are made at night because the action of sunlight powerfully increases the scalding effect of the gas on the leaves. Most of the work is done by contract or under

METHOD OF OPERATING TENTS IN THE HYDROCYANIC ACID GAS TREATMENT.

the direct supervision of the county horticultural commissioners. In Los Angeles County the horticultural commissioner furnishes tents and material at a mere nominal charge, together with one experienced man to superintend the work, while a crew of four men operate the tents. The wages of the director and men are paid by the owner of the treés.

The tents now employed are of two kinds, the "sheet" tent of octagonal shape for large trees, and the "ring" tent for trees under 12 feet in height. The ring tents, or, as they are also called, the bell tents, shown at extreme right in Pl. V, are bell shaped and have a hoop of half-inch gas pipe fastened within a foot or so of the opening. Two men can easily throw one of these tents over a small tree. An equipment of 36 or 40 ring tents can be handled by four men. They are rapidly thrown over the trees by the crew, and the director follows closely and introduces the chemicals. By the time the last tent has been adjusted the first one can be removed and taken across to the adjoining row. An experienced crew, with one director, can treat 350 to 400 five-year-old trees averaging in height 10 feet in a single night of eleven or twelve hours. The cost under such conditions averages about 8 cents a tree.

With large trees the large sheet tents are drawn over them by means of uprights and pulley blocks, as illustrated in Pl. V. Two of these sheets are necessary for very large trees, the first being drawn halfway over and the second drawn up and made to overlap the first. In the case of trees from 24 to 30 years old and averaging 30 feet in height, about 50 can be treated in a night of ten or twelve hours, with an equipment of 12 or 15 tents, the cost being about 75 cents per tree. It is not feasible to treat trees above 30 feet in height.

Through the courtesy of Mr. John Scott, referred to elsewhere, and Mr. A. T. Currier, the owner of an orange ranch near Spadra, Cal., the writer was given an opportunity of witnessing the method of operating both the sheet and bell tents. The handling of the bell tents is simple and needs no further description, but the large tents are not so easily operated, and the method of adjusting the great flat octagonal sheets over the trees, while simple enough when once understood; will have, perhaps, some interest for Eastern fruit growers who may desire to experiment with the hydrocyanic acid gas. The only machinery employed consists of two simple uprights, with attached blocks and tackle. The uprights are about 25 feet high, of strong Oregon pine, 2 by 4 inches, and are provided at the bottom with a braced crossbar to give them strength and to prevent their falling to either side while the tent is being raised. A guy rope is attached to the top of each pole and held to steady it by two of the crew stationed at the rear of the tree. The tent is hoisted by means of two ropes 70 feet long, which pass through blocks, fixed, respectively, at the top and base of the poles. The tent is caught near the edge by

taking a hitch around some solid object, such as a green orange, about which the cloth is gathered. By this means the tent may be caught anywhere without the trouble of reversing and turning the heavy canvas to get at rings or other fastenings attached at particular points. The two remaining members of the operating crew draw the tent up against and over one side of the tree by means of the pulley ropes sufficiently to cover the other side of the tree when the tent falls. The poles and tent together are then allowed to fall forward, leaving the tent in position. Sufficient skill is soon acquired to carry out rapidly the details of this operation, so that little time is lost in transferring the tents from tree to tree, even when the trees approximate the limit in height, as was the case where the operation was witnessed. A single pair of hoisting poles answers for all the tents used.

Some practical experience is necessary to fumigate successfully, and it will therefore rarely be wise for anyone to undertake it on a large scale without having made preliminary experiments. If the cyanide treatment is to be introduced in the East, it would be well for fruit growers to obtain the services for a year or more of an experienced man from California to give them a practical illustration of methods, and even in California it is recognized that such work is much more economically accomplished when given over to experienced persons and done under contract. The gas treatment is probably the most thorough of all methods, but complete extermination is very rare. Fumigation must therefore be repeated every two or three years, or as often as the scale insects reappear in any numbers.

The canvas employed in the construction of tents may be rendered comparatively impervious to the gas by painting lightly with boiled linseed oil. This has the objection, however, of stiffening the fabric and adding considerably to its weight; it also frequently leads to its burning by spontaneous combustion unless carefully watched until the oil is dried. A much better material than oil is found in a product obtained from the leaves of the common prickly pear cactus (*Opuntia englemanni*), which grows in abundance in all the southern counties of the State. The liquor is obtained by soaking chopped-up leaves in water for twenty-four hours. It is given body and color by the addition of glue and yellow ocher or venetian red, and is applied to both sides of the canvas and rubbed well into the fiber of the cloth with a brush.

STEAM AND SUPERHEATED WATER.

The use of steam for destroying insects is not a new method, but has recently been extensively experimented with by Dr. S. M. Woodbridge, of South Pasadena, and the writer was given an opportunity to witness the process and to note the results of earlier experiments. The method is very simple and practically identical with the gas treatment just described. The steam is generated in a boiler, the one employed carrying 80 pounds, and is introduced into the tent by means

of a hose. As practiced by Dr. Woodbridge, the hot steam is first directed by hand over the trunk and larger limbs; the end of the hose is then inserted in a box which has been perforated with inch auger holes, the object being to so distribute the steam in the tent as to prevent its burning the foliage by striking forcibly in one direction. The steam is left on until the temperature, determined by an inclosed thermometer, rises to 120° F. in the tent. Two degrees higher will not injure the tenderest growth, but a temperature of 125° and upward will kill every blossom, bud, and leaf. The time required to bring the tent to the proper temperature varies with the day and prevailing winds. A tent 10 by 12 feet in diameter can be brought to the temperature named in from five to ten minutes. When the necessary degree of heat is reached, the steam is partly shut off and the mercury maintained at the desired point for seven or eight minutes. The tent is then removed. On the trees treated to the limit of safety, as described, the red scale is killed on the leaves and twigs, but is not affected on the fruit. It is claimed for this process, on which there is no patent, that it is much cheaper than the use of gas, and that a 25-horsepower boiler will furnish steam in ten hours for 100 trees averaging 25 feet in height. Further advantage claimed for this treatment is that it is said not to affect beneficial insects. The objections to the treatment are the necessity of carrying a cumbersome steam apparatus through the orchard, and the fact that the tents are liable to become wet from the steam and difficult to handle. It is also less successful than gas, which kills the scales on fruit as well as on leaves and twigs. The experiments, however, have demonstrated that good results can be obtained, and it is possible that in future something practicable in the destruction of scale insects may be accomplished with steam.

In connection with the above experiments a demonstration was given of the use of superheated water. This also necessitates the use of a steam engine, as in the former case. The water, which may contain an insecticide or be used merely as a hot spray, is raised to a temperature in the boiler indicated by 40 pounds pressure. This, when liberated through a nozzle at the extremity of a long hose, is equivalent to a pressure of about 150 pounds. The liquid escaping from the hose breaks up into a forcible, half-steam spray even with a very simple nozzle formed by compressed gas pipe, and is directed onto trees as in ordinary spraying operations. The principal advantages are that the spray pump is dispensed with and that the liquid is applied at an elevated temperature. The spray is, however, cool to the hand in the center of the stream at a distance of 18 inches and on the edges at a distance of 8 inches from the nozzle, and is not too hot to be borne by the hand at a distance of 6 inches from the nozzle. This indicates that the temperature of the liquid itself will not ordinarily be sufficient to kill the insects.

These experiments were especially interesting as indicating the futility of attempting to kill insects by means of hot sprays. The difficulty of recharging the apparatus and the cost of the steam plant will probably render this, as a method of applying liquid insecticides, impracticable in comparison with the gasoline-spray engines and ordinary spray pumps now in use.

KEROSENE EMULSION.

This well-known insecticide is used to a very considerable extent in California, much more so in recent years than formerly. It is the principal insecticide used in the district about San Diego, and is also used extensively at Santa Barbara and to a less extent elsewhere in the State. The necessity for the use of very large quantities of insecticides in California has led to the establishment by private parties in several instances of steam or gasoline plants for the production of this insecticide wholesale. Probably the first extensive manufacturing plant of this sort was set up by Mr. W. R. Gunnis, county horticultural commissioner, of San Diego, who manufactures the emulsion by the aid of a small engine, doing all the work of heating, churning, etc., by this means. With coal oil at 11 cents per gallon, he is able to produce the emulsion at a charge of 13 cents per gallon in the undiluted state, which makes the wash as applied to the trees, diluted 7 times, cost a little over 1½ cents per gallon. In his district, Mr. Gunnis claims that the loss from scale insects has been reduced from 79 per cent to 7 per cent, chiefly by the use of this wash.

At Santa Barbara, the superintendent of the Las Fuentos ranch, Mr. Frank Kahles, has set up a very large plant for the manufacture of kerosene emulsion for the use of this ranch alone. The plant is similar to that devised by Mr. Gunnis, and the capacity is such that the emulsion can be made in quantities of 150 gallons at a time and very rapidly. He uses a formula slightly different from the Hubbard. The proportions are 35 gallons of whale-oil soap, 100 gallons of kerosene oil, and 50 gallons of water. This is diluted for application to trees with 7 parts water, costing in the diluted state 1⅜ cents per gallon.[1]

Kerosene emulsion has probably been given its most extensive trial on the Pacific Coast at the Las Fuentos ranch. Two years since Mr. Gunnis sent his excellent spraying apparatus to Santa Barbara, together with some 8,000 or 10,000 gallons of emulsion, and thoroughly sprayed the lemon plantings, comprising upward of 25,000 trees. The

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[1] Mr. Kahles was formerly connected with a royal garden in Bavaria. He states that kerosene emulsion was used thirty years ago by Herr Schoenfeldt, the head gardener in the establishment. Soap was dissolved in hot water, kerosene added, and the whole agitated for fifteen or twenty minutes until an emulsion was formed. It was used as a wash for greenhouse and other plants. This seems to be a reliable record of the use of kerosene emulsion much older than any records hitherto given.

present season Mr. Kahles has, with spraying apparatus made from a photograph of the Gunnis machine, twice sprayed all the lemon orchards with the emulsion. By the Gunnis treatment many trees were killed, owing probably to the accumulation of oil in the bottom of the reservoir or tank, so that the last 3 or 4 trees with each filling received an unusually heavy dose, which, running down the trunk, collected in the cavity about the crown caused by the swaying of the trees in the wind. The accumulation of oil is obviated in the new apparatus constructed by Mr. Kahles by giving the tank a conical bottom, so that the liquid may be thoroughly exhausted each time before refilling, and as a further precaution, before treating, the trees are mounded up about the base and the earth thoroughly compacted.

With these precautions no injury has resulted from the later sprayings. The last treatment was given in September and October, 1896, the trees having again become thoroughly reinfested with the black scale and much blackened. Since the treatment the trees are responding very rapidly in new vigorous growth and the fungus is rapidly peeling off, all the scales which had hatched prior to the application having been killed. In this region, however, the black scale hatches very irregularly, and a good many young scales have since appeared which will make a later spraying necessary.

RESIN WASH.

This wash is a distinctively Californian insecticide, used much more generally than kerosene emulsion and ordinarily employed in the important citrus districts extending from Los Angeles to Redlands. It is often prepared and the work of spraying is often done by contractors, who agree to clear orchards from scale at a given charge per gallon, usually 4 cents. For small trees 5 years old and under, 1 gallon is sufficient per tree. Trees of 20 or 30 years' growth require from 6 to 8 gallons.

The formula for this wash varies in different sections. The summer wash usually contains 20 pounds of resin, 5 pounds of crude caustic soda (78 per cent), or 3½ pounds of the 98 per cent, and 2½ pints of fish oil. The winter wash contains 30 pounds of resin, 9 pounds of crude soda, and 4½ pints of oil. The ingredients are boiled in about 20 gallons of water for two or three hours, hot water being occasionally added until 50 gallons of solution are made. This for both formulas is diluted to 100 gallons before application to trees. Greater efficiency is believed to come from long boiling of the mixture, and it is preferably applied hot. It is used on deciduous trees for the black and San Jose scales and on citrus trees for the red and black scales, but the dense foliage of the latter renders thorough spraying difficult except for young trees, and fumigation is much preferred. An improperly made resin wash is also apt to spot the fruit of the orange.

THE DAYTON WASH.

This is a petroleum compound manufactured at Cleveland, Ohio, and sold at $1.25 per gallon. It has been used at Riverside for the past year instead of kerosene emulsion or resin wash. It is said to be nearly as effective as either of the latter and is much cheaper, costing, applied to the trees, about 2 cents per gallon. It is used in dilutions of 1 part to 80 or 1 part to 100 of water for the young of the black scale. For the red scale a much stronger mixture is required. It does not spot the fruit. This wash is not claimed to be the equal of the resin wash, but the failure of the orange crop at Riverside, due to the frosts of the winter of 1895–96, has discouraged growers, and they are unwilling to go to the expense of the resin or gas treatments. It is used chiefly against the black scale, which, in the newly hatched condition, is comparatively easy to destroy.

LIME, SALT, AND SULPHUR WASH.

This is the almost invariable remedy for the San Jose scale in California, and over much of the State it is undoubtedly very effective. Experience with this wash in the East had thrown doubt on its real efficiency as an insecticide, and it has been clearly demonstrated that in the climatic conditions east of the Alleghanies it is almost valueless. In California, however, the demonstration of its usefulness against the San Jose scale is complete and the benefit of its application to orchards is most manifest. In the vicinity of Pomona, Cal., some unsprayed orchards were visited which were as badly infested with San Jose scale as any of our Eastern orchards, while in adjoining sprayed orchards the scale was entirely killed and the trees were rapidly recovering and showing vigorous and healthy new growth. In contiguous orchards, also of the same kinds of trees, similarly treated so far as cultivation is concerned, the trees which had been subjected to yearly spraying were at least one-third larger than untreated trees. This wash is of value also as a fungicide, protecting stone fruits from leaf fungi, and is also a protection against birds, the common California linnet doing great damage to buds in January and February. The wash is almost invariably made and applied by contractors, and costs about 5 cents per gallon applied to the trees. It is a winter application, being applied in January and February.

Along the coast region and in northern California, where moister conditions prevail, this wash is very much less successful, bearing out somewhat the experience of the East and doubtless explained by the similarity of climate in the districts mentioned with that of the Atlantic Seaboard. In making this wash the chief consideration seems to be prolonged boiling. The wash itself is practically a sulphide of lime, with free lime and salt carried with it. Prolonged boiling will result in taking up additional sulphur, and will perhaps add to its caustic

properties. The proportions of the ingredients and the method of combining them varies slightly in different sections. The following is the ordinary formula: Unslaked lime, 40 pounds; sulphur, 20 pounds; salt, 15 pounds; one-fourth of the lime is first slaked and boiled with the sulphur in 20 gallons of water for two or three hours; the remainder of the lime is slaked and together with the salt is added to the hot mixture and the whole boiled for a half hour or an hour longer. Water is then added to make 60 gallons of wash. This wash is applied practically every year, or as often as the San Jose scale manifests itself in any numbers. In the coast region and in the northern part of the State it is necessary to apply it with greater frequency than in the interior districts.

INSECTICIDE MACHINERY.

The apparatus for applying liquids to trees in California are practically as used elsewhere. For many years back the means have been simple spray force pumps of various styles, usually of not very great capacity. Of late years stronger hand pumps, usually with air-pressure reservoirs, have been employed, and in several notable instances well-equipped power spraying apparatuses have been constructed and used successfully from one to several years. The first power spraying apparatus used was the one manufactured by Mr. W. R. Gunnis, referred to and described in an article by Dr. Howard, "The use of steam apparatus for spraying" (see pages 73 and 74). Thousands of trees have been sprayed with this machine about San Diego, and it has also been extensively used in other parts of the State. This machine has been the basis for at least two others, one of which has been employed for a year or two at Riverside, and the other is employed on the Las Fuentos ranch, Santa Barbara. With these machines the operation is very rapid and is carried on with an efficiency not hitherto equaled with any other apparatus used. For the details of the construction of these machines and the methods employed in refilling in the field, so that no time is lost, and other points concerning them, reference may be made to the article cited above.

CONCLUSION.

In taking this general view of the insect problem in California, one is impressed first with the fact that the peculiar conditions of climate, particularly of heat and moisture, and the system of cultivation which these necessitate are really more important considerations than any others in the control of insects; and as these very conditions are more or less local, many of the measures which are successful in California will prove impracticable or inapplicable elsewhere. The use of gas, for instance, which is so very successful in California with citrus trees, can not be easily employed in our Eastern deciduous orchards. It will, however, apply to the citrus groves in Florida as well as in

California. Many of the washes employed in California owe, as has been pointed out, their efficiency to climatic conditions, and unless these conditions are duplicated elsewhere these washes can not be expected to give similar results. This applies particularly to the lime, sulphur, and salt wash, and to some extent also to the resin and other washes. Of much greater value, however, to Eastern horticulturists is a study of the system of minute orchard inspection practiced in California, which, after all, is the most valuable feature in her measures for the control of insects and plant diseases. The importance of immediate discovery of injury before it has become established needs no especial emphasis. Such orchard inspection, with supervision of treatment, in connection with a system of quarantine, will do much for Eastern fruit growers. It may be impossible to accomplish such work with the same efficiency and thoroughness as on the Pacific Coast, due to the greater difficulty of extending inspection and treatment over scattered areas of much wider extent, but that immense good can be gained can not for a moment be doubted. The present system in California is not a theoretical or experimental one, but is the outgrowth of the practical experience of years, and it is within the power of Eastern fruit growers, by adopting California methods so far as they can be made to apply, to save years of experimentation, which in the end would probably bring about a similar system, but only after immense loss to the fruit interests had been incurred.

DISEASES OF SHADE AND ORNAMENTAL TREES.

By B. T. Galloway and Albert F. Woods,

Chief and Assistant Chief, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

GENERAL REMARKS.

Speaking generally, the diseases of trees may be divided into two classes: (1) Those in which conditions of soil and climate are the controlling factors, and (2) those where parasitic enemies, such as insects and fungi, are the principal agents involved. Some of the more important insects were described in the Yearbook for 1895, and therefore the present remarks will be confined for the most part to the diseases in which conditions of soil and climate and parasitic fungi are involved.

No sharp line can be drawn between the two classes of diseases to which reference has been made. If they were controlled by a single set of factors, this might be done, and the question of identifying them would then be a very simple matter. Complications, however, are always involved, and these become more intricate the more they are investigated; in other words, the tree is ready at all times to adapt itself, within certain limits, to surrounding conditions, and in doing this elements of weakness may be developed which will result in disease or death. The adaptability of trees, therefore, to environment is a most important matter in considering the question of diseases, and to properly understand the latter it may be well to briefly review some of the more important points involved in the former.

It is a matter of common observation that different types of soil and climate support different kinds of trees and other plants. It is not always, however, because we find certain kinds of trees growing in certain soils and under certain conditions, that the peculiarities of the soil and surroundings account for their growing there. Such trees may grow very much better under different conditions if an opportunity is offered; otherwise they will continue to grow where they are, at the same time tacitly protesting against their environment by responding to the more suitable surroundings if they appear.

An important matter for consideration in the question of adaptation of plants is the fact that the individual is much more susceptible to changes than is the species as a whole. For example, an individual white oak tree in a moist, warm region would make a growth which would quickly dry up if moved to a region where moisture is deficient,

but where other white oaks were growing, whereas if it had been started from the first in the dry region it would have adapted itself to the conditions and thrived there. Conversely, the tree growing in a dry region or place, if moved to a wet location, is liable to suffer, as it is unable to adjust itself to such a sudden change. It is a common practice to transplant trees from the forest to yards and other places where the conditions of soil and air are quite different from those under which the plant originally grew. In such cases it is difficult to get the trees to live, owing to their inability to adjust themselves to the new requirements. If they do not entirely succumb to the effects of changed surroundings, they may, during the period in which they are trying to adjust themselves, be attacked by parasitic enemies, which will simply result in death in another form.

From such facts as here adduced it would appear that disease or death of trees is largely the result of combinations of unfavorable factors, and that where these latter are favorable to the performance of the normal functions of the trees they might continue to live indefinitely. Unlike an annual or biennial plant, a tree renews itself each year by a thin layer, which forms between the old bark and the wood. This layer is the starting point for the next generation, so that we have a great mass of dead and dying generations within, coated outside with a live generation, which is just as distinct individually from previous generations as a new plant produced from a cutting or bud is distinct from the parent, and which, therefore, strictly speaking, is never old.

As long as the conditions for obtaining food and water from the soil and for conducting these to every part of the tree are favorable and the effects of climate are not detrimental to growth, the living portion of the tree should be as vigorous as ever. These conditions, however, are seldom attained, and as a result the duration of life is long or short according to the ability of the tree to overcome the difficulties in the way of its development. Thus, if there is a continual drain on the supply of soil foods, with no addition, the tree will eventually starve to death or become so weakened that it will succumb to the attacks of parasites; a period of drought may kill many feeding roots, branches, and leaves, and as these decay openings will be left for parasitic fungi; a period of cloudy, wet weather may do the same by asphyxiating many roots and leaves; a severe cold spell may "kill back" young growth and injure the young leaves in the spring; a late, warm, and moist fall after a dry summer may induce a fall growth which can not mature sufficiently to withstand winter cold, and is thus "killed back;" insects may defoliate the branches and borers mine the trunk and limbs, and thus cut off the distribution of food and water and make openings for the entrance of parasitic fungi; parasitic fungi may attack some part of the tree under certain favorable conditions without the tree being previously injured; a tender vegetative growth,

although perfectly healthy and normal, may at a certain phase of development be unable to resist the attacks of certain parasites, while later the parasite may not be able to gain entrance; the chemical composition of the juices, or the prevalence of sugar, starch, and acids or bases, may make it possible for parasites to attack the tissues during certain stages of growth, and thus produce disease.

From the foregoing, it will be seen that any disease, no matter how simple it may appear on the surface, involves complications which require careful study, and it is only such study that will enable the intelligent grower to obtain the highest success in his work.

DISEASES DUE TO SOIL CONDITIONS.

LACK OF FOOD AND WATER.

A disease known as "stag head" or "top dry" frequently results from lack of proper food in the soil. The trouble manifests itself by the gradual death of the top of the tree, the lower branches remaining green, but making little active growth. It is common in forests, especially where the conditions have been changed by cutting out or burning the undergrowth, by greatly thinning out the trees,[1] or by excessive drainage of moist areas. It often appears in parks where the natural undergrowth has been cut out and the trees have been thinned, thus exposing large areas to the sun and the washing effects of heavy rains. In such cases there is at first, as Hartig points out, an accelerated decomposition of the humus which covers the soil. At the same time the manufacture of sugar and starch by the leaves is increased, owing to an increased supply of light. Stimulated by this increase of food, all the benefited trees make a more vigorous growth, dormant buds developing into leaves and branches, especially in the previously shaded lower parts of the trees. This may continue for a few years, or until the stock of humus and other available food material is reduced. The soil then dries out to a considerable depth during the summer, and as a result many of the upper feeding roots are killed, the natural processes which render plant food available are interfered with, and starvation begins. As the soil becomes poorer and poorer the lower branches appropriate most of the food and water and the upper ones, not being able to obtain their share, die.

Trees planted in parks, in yards, and along streets are especially subject to this disease. Growing year after year where there is no addition to the available soil foods, especially nitrogen, and where the soil is dried out by the sun and grass, starvation necessarily follows. The tree therefore gradually stops growing, the branches and limbs slowly die, and other diseases set in, until finally the last branch is dead. Another cause of this trouble is often found in the process of grading, which removes what good surface soil there is, leaving one

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[1] Hartig, Diseases of Trees, pp. 270–272.

not only of poor physical quality, but also lacking in nitrogen, if not in other available soil foods. In planting trees in such places a hole, possibly of sufficient size, is dug, and the tree is set in this, probably with some richer soil, which will furnish food for an indefinite period, according to its quality and amount. If the quality of the soil is poor and the amount small, the tree will begin to starve in five or six years; if the quality is better and the amount larger, it will last for a much longer period. But no matter how good the soil may be to start with, unless the food supply is properly renewed it is sure to become exhausted as far as the tree is concerned, and starvation, with all its incidental troubles, will follow. (Fig. 53.)

Preventive measures.—It is evident that a constant supply of proper food is necessary to prevent this disease. If the soil is naturally rich, well drained, and of good texture, little need be done in the way of improving it. Wherever practicable, the ground underneath the tree should not be completely sodded, but should be planted to low-growing, shade-enduring plants, so that most of it may be worked and top-dressed each year, thus keeping up the food supply and the proper aeration of the soil. The poorer the soil the greater the precautions that must be taken in this direction. When trees are to be set in very poor soil, as is often the case in cities, a hole at least 8 feet long, 2 feet deep, and 3 feet wide should be excavated and good soil substituted for that removed. Along streets and walks as large a parking as possible should be left around the tree. Each year this should be spaded as deep as possible without injuring the roots, and then top-dressed with good rotten manure enriched by a sprinkling of ground bone. Grass or weeds should not be permitted to grow in this area, nor should the ground be allowed to become trampled down. If these precautions are taken, the health and life of the trees will be extended many years beyond what they would under less favorable conditions.

IMPERFECT CIRCULATION OF AIR IN THE SOIL.

The proper aeration of the soil has an important bearing on the health of trees. The amount of air and its circulation are affected by the size and arrangement of the soil grains, amount of water present, proximity of pavements, filling, grading, etc. Whatever may be the cause of imperfect aeration, the effects are far-reaching and important. In the first place, nitrifying organisms can not carry on the important process of fixing atmospheric nitrogen in soils deficient in air, especially its most important element, oxygen, while other similar organisms may even cause the destruction of what nitrates there are present. This is particularly true of wet soils and those of very close texture. The presence of much water between the soil grains prevents the circulation of air, and there is consequent loss of nitrates, the most valuable of all soil foods. But aside from this important consideration the plant roots themselves require a plentiful supply of

oxygen in order to carry on their own life processes. Growth can not take place without it, neither can the formation of reserve materials. These processes are especially active in roots. A deficiency of oxygen for roots at once becomes apparent by cessation of growth, and, if too long continued, by the death of the roots, followed by starvation and death of the whole plant.

Trees are often injured in poorly drained soils during a wet period. Of course, if the presence of water is constant and the tree has grown up under these conditions, it will produce many surface and water roots, thus adapting itself to a wet situation. We refer here, however, especially to soils which are too wet only at certain periods—low places, underlaid by hard pan; where ground water comes close to the surface; or in stiff soils, which, becoming saturated, hold water for a long time. The roots produced in the rather dry or moist soil are injured or killed during wet periods, especially the deeper ones, like the tap-root and the lower laterals. A prolonged wet period followed by a very dry one is liable to completely kill the tree under such conditions. In some of the close-textured soils of the West and Southwest, naturally deficient in aeration, trees often suffer or are killed during the rainy season, or by excessive irrigation. When the roots are not killed, they are so weakened as to be made subject to the attacks of various root-rot fungi.

FIG. 53. Stag head soft maple.

Trees planted along the paved streets of towns or cities nearly always suffer from a lack of aeration of the soil. The exchange of gases between the soil atmosphere and the air is greatly retarded by pavements and walks and by the hard-packed surface of roads which are not paved. This trouble is especially liable to occur along streets,

where the ground water is only a few feet from the surface. During prolonged rainy weather the water rises, making the soil wet up close to the surface. The pavement adds here to the evil of poor underdrainage, preventing evaporation and aeration.

Another means of cutting off the soil air is by filling and deep planting. It often happens in grading that soil is filled in around trees, sometimes to a depth of several feet. In naturally well-aerated soils the damage that may result from this practice is not so great or so soon apparent. No special harm may result in such soils if the amount added is not more than a foot in depth, but where it exceeds this more or less rapid asphyxiation of the roots and lower part of the trunk will follow. The tree may not be killed, but it will at least be greatly checked and stunted in growth, making it more subject to other diseases.

The same troubles often result from too deep planting, especially in heavy soils. The deeper roots rot, and the tree makes a slow, stunted growth, and sometimes lasts for many years, when it either dies of its own accord, is blown over by the wind, or death is hastened by some parasitic disease. Large numbers of young trees set only a few inches too deep are killed in this way.

Preventive measures.—In all cases where there is a lack of aeration steps should be taken to keep the ground around the trees stirred. In cities parking must be left, and where the ground is hard it should be frequently spaded to a depth of 6 to 8 inches, as already described. Where the ground has been filled in around the trees, the latter, if not too old, may be saved by removing small patches of bark down to the wood. This should be done at points beneath the soil so as to induce the formation of new roots from the wounds. Some trees, like willows, poplars, beech, and horn beam, but especially shrubs, produce adventitious roots just beneath the surface of the ground, and these are able to preserve the trees though the deeper roots may be killed.

GASES AND OTHER POISONOUS SUBSTANCES IN THE SOIL.

Asphyxiation of the roots of trees is sometimes produced by illuminating gas which has escaped from some gas main near by. It probably also acts as a direct poison. Diseases produced by other poisonous substances in the soil or by too great concentration of substances not poisonous are too rare to warrant their treatment here. The injuries from escaping gas can be remedied only by stopping the leak, and after removing as much of the old soil as possible filling in with fresh, rich earth.

DISEASES DUE TO ATMOSPHERIC CONDITIONS.

As already pointed out, no sharp line can be drawn between the diseases due to conditions of the soil and of the air. As a matter of fact, a weakened state of the tree, due to certain conditions of the soil, will make it all the more liable to succumb to atmospheric

influences. Again, it may happen that very favorable conditions of the soil may start growth at a time when it might be injured by cold or other conditions of the atmosphere.

DESICCATION, OR DRYING OUT.

Young leaves and sometimes tender shoots which have pushed out during a spell of cold or cloudy, moist weather frequently wither and die when suddenly exposed to bright, hot sun. This is ordinarily called sun scald. It is not, however, a true scalding of the tissues, but is due to the fact that the latter lose water more rapidly than they can obtain it, and so wilt and dry out beyond the power of recovery. The excessive loss of water is brought about mainly by the leaves produced in very moist air not being adapted to resist excessive evaporation, even when there is an abundant supply of water in the soil and in the main parts of the plant. The trouble occurs more often in spring, when growth is rapid, and cloudy, moist days are followed by hot, dry ones. Later in the season the death of the margins and tips of the leaves of a great variety of trees, shrubs, and other plants is often observed. This is especially noticeable when a rather moist spring, favorable to growth, is followed by dry and very hot weather. Trees making a poor, stunted growth suffer most, although any tree is liable to injury if the right conditions prevail. In parts of the West and Southwest the disease described is produced in a very short time by hot, dry winds, which sometimes sweep over the country. Frequently the leaves are literally cooked, but oftener the edges wilt, turn red or pale yellow, and then dry up.

Desiccation may also occur in the winter; in such cases parts of the tree or even the entire tree may be killed. Evergreens, especially pines, are frequently seriously injured from this cause. A few warm days occurring at a time when the roots are frozen or when the ground is so cold that it hinders root action, cause the needles to turn reddish yellow and fall. Frequently only the tips of the needles at the ends of the branches are affected, and again young and exposed trees may be thoroughly dried out and killed. Cold, dry winds may bring about the same effects as warm ones with sunshine. Any conditions, in fact, which will cause a more rapid evaporation of water than the roots can supply will, if continued a sufficient length of time, eventually result in the injuries described.

Preventive measures.—In cases such as have been referred to it would be difficult to carry out remedial measures. In most instances the injuries are done before any steps are taken to prevent them, and of course it is then too late to save the tree or the parts of it that may have been injured. The efforts of growers, therefore, should be largely toward keeping the trees in such condition that the injuries may be prevented. The means of preventing summer desiccation, while simple in themselves, are not always easily carried out. In

cases where the injury results from imperfect root action owing to soil conditions, the latter may be changed by drainage, by cultivation, and in other ways by which more air is given to the roots. If the soil is too dry, as is often the case, its water-holding capacity may be improved by proper cultivation, by the addition of organic matter or humus, by mulching, etc. Top-pruning in dry seasons will often check the excessive demand for water and thus prevent injuries to the remainder of the tree. At present there seems to be no practical way of preventing the sudden damage which may be done by hot winds, except by copious watering of the soil, and even this may not always prevent serious injury, owing to the rapid evaporation at such times.

In the matter of preventing the winter "blighting," or drying out, of evergreens, every effort should be made to keep the roots in such condition that they can respond when a demand for water is made upon them. It is evident that if the soil is well dried out when winter sets in injury will result whenever the conditions already described prevail. When practicable, therefore, liberal applications of water to the soil may enable the trees to successfully pass through winters which, if such precautions were not taken, might prove injurious. Liberal mulching with straw or manure may also prove beneficial both as a conservator of the moisture and as a means of preventing the ground from freezing too deep and hard.

The most trying time for the trees is when they are young and small, that is, before the roots have extended very deep into the soil. At very little expense, however, such trees may be protected from both wind and sun by straw.

EXCESS OF ATMOSPHERIC MOISTURE.

During periods of long-continued rains or fog, evaporation from the leaves of trees is slow, and as a result the entire plant becomes charged with water. One of the results of this is an unusual mechanical stimulation of growth, and this growth is increased by changes in the cell contents, which give the cell in question an abnormal attractive power for water. Under these conditions nutrition is interfered with and the growth produced is thin-walled, unhealthy, easily dried up, and a ready prey for insects and fungi. Older parts of the plant are affected by these conditions in various ways, one being the production of little warts and swellings by the abnormal growth of cells, as described above. These may appear on leaves or stems, the tissues of which still possess some power of growth.

It often happens that leaves in the diseased condition described become water-logged in spots. This is especially common where two leaves are stuck together with a film of water, instances of which have been observed this year on the Norway, the hard, and the soft maples, as well as on various other trees and shrubs. The close

contact of the water with the cells of the leaf is very favorable to its absorption. Wet, translucent spots appear, especially around any little injury like the puncture of an insect or tear in the leaf surface. The presence of this water between these cells cuts off their supply of oxygen, and consequently they soon die and turn brown. The same trouble occurs when the leaf surface remains wet for twenty-four to forty-eight hours, even though not stuck to another leaf. The conditions about Washington, D. C., for example, have been unusually favorable to this trouble during the present season. In early spring vegetation was at first a little retarded by cool weather, but this was suddenly followed by good growing weather, during which the leaves of most trees and shrubs, especially those of Norway maples, pushed out with great rapidity. This latter period was followed by one quite dry and warm, during which red spiders increased to unusual numbers, particularly on the lower and more protected leaves of the crown. After this came a period of several days of rainy weather, and many of the spiders were washed off, but the leaves where they had been working became water-logged, as described elsewhere. The Norway maples and horse-chestnuts suffered most, the leaves of these trees in many cases appearing to have been scorched by fire.

Preventive measures.—Water logging and other injuries resulting from an excess of moisture in the air are not easily prevented; in fact, it is questionable whether anything practical can be done in such cases. However, trees can be made much less liable to such trouble by proper care in planting, feeding, etc. As already described, such trees as Norway maple and horse-chestnut, which are peculiarly susceptible to injuries of this kind, require special care, and it is a question whether it would not be best in the end to discard them entirely where the conditions are such as to make it almost impossible to keep them in health.

LOW TEMPERATURES.

The injuries from freezing are closely related to those brought on by desiccation. In fact, freezing of the tissues is a drying out of the water which they contain. If the tissues are dried beyond the point where they are able to again take up water, they are killed.

In a state of maturity and rest most of our trees and shrubs indigenous to regions subject to frosts stand freezing without the slightest injury, provided they do not thaw out too rapidly. In case of plants introduced from warmer climates, however, all degrees of ability to withstand cold are to be found, some being killed by the slightest frost, while others appear to adapt themselves readily to the changed conditions and withstand quite severe freezing. The fact that trees, especially exotics, growing in wet situations are more easily injured by cold than those growing in drier places, is probably because the former do not mature their growth, while the latter do to a great

extent. This is true also as regards the more succulent parts of plants, which are notably more subject to frost injury than the drier portions. Smooth-barked trees sometimes have their trunks and larger branches injured on the southwest side during winter, the injuries being characterized by the death of large patches of bark. During the latter part of winter and early spring, when there are periods of several days of warm weather, the cambium on the south side of the trunk and larger limbs is stimulated to premature activity. If the warm spell is followed by cold, freezing weather, these partially active areas will be killed, after which they gradually dry out, the bark, young wood cells, and cambium shrinking. After a time the bark separates from the wood and finally splits. This may not occur until pretty well into the summer months, and may not then be evident except upon close examination. During rains these portions become water-soaked, various ferment and decay-producing fungi gain entrance, and the rotting of that part of the trunk begins, extending rapidly from year to year, until the tree either blows over or is killed.

Cracks occur in a great variety of trees during very cold spells, especially when the fall of temperature is very sudden. It is a well-known fact that trees shrink under the influence of intense cold in the same way that felled timber does in drying. This shrinkage is due to the withdrawal of water from the cell walls, in the first case by freezing and in the second by evaporation. The extent of shrinkage is dependent upon the amount of water withdrawn. The cell walls of the outer new wood usually contain more water than do the walls of the heartwood. The outer wood will shrink in drying more than will the inner wood and will therefore split. The chance of splitting is greater when the outer-wood layers freeze before the inner ones, as they do during a sudden fall of temperature. This is Hartig's explanation of frost cracks and the one which has the most experimental evidence in its favor. Other explanations have been given, but it will be unnecessary to discuss them here. The cracks usually close up again during warm weather and ultimately heal over, doing little damage to the trees from the standpoint of this article.

Preventive measures.—The injuries to the trunks and branches by alternate freezing and thawing and the diseases resulting from them may be prevented by shading the parts exposed to the sun by means of a board set up on the south side of the tree, or, as is sometimes done, by screening the parts with straw, burlap, building paper, or other material which may be easily fastened to the trunk and branches. When once injuries of this kind have been produced, the dead areas should be cut out down to the healthy wood and the wound thus made covered with coal tar, varnish, or "hard oil."[1]

[1] Yearbook of the U. S. Department of Agriculture for 1895, pp. 257–300.

INJURIOUS GASES IN THE AIR.

In the vicinity of manufacturing establishments and often in cities and villages where large quantities of bituminous coal are used, vegetation, especially trees and other woody plants, are frequently seriously injured by the fumes which are thrown off into the atmosphere. Smelting works, fertilizing manufactories, brick kilns where soft coal is used, and similar establishments are the principal agencies involved. Frequently the injuries may be limited to a small area immediately adjacent to the factory or other place from which the fumes are given off. Again, the effects of gases may be seen for several miles, usually extending farthest in the direction of the prevailing winds. The effects of such gases on the trees are various, and it is often difficult to distinguish the injuries produced in this way from those resulting from purely climatic causes. From the evidence at hand it appears that the chief injury in such cases is due to sulphurous and hydrochloric acids, acting singly or in combination. The effects of these poisons are shown by the leaves turning reddish brown in spots or along the edges and eventually drying up entirely. The injuries are cumulative, certain branches of the trees being killed each year, while the others may make a feeble, struggling growth, owing to the cutting off of the food supply through the injuries to the leaves.

Preventive measures.—The question of remedying or preventing such evils is an important one and may often involve complicated legal questions. It may happen that the establishment of a factory in a certain neighborhood will result in much injury to farmers in the immediate vicinity by destroying their trees and crops. All the evidence goes to show that little can be done toward mitigating the trouble in the way of special apparatus for collecting the gases, high chimneys, etc. The question therefore resolves itself into one respecting the rights of the farmer on the one hand and the factory owners on the other. These matters, however, are beyond the province of this article.

FUNGOUS DISEASES.

All portions of the tree are subject to the attacks of fungi—minute parasitic plants, whose vegetative parts, known as mycelium, penetrate the tissues and by their action on them cause the various forms of blight, rot, etc. The fungi are rapidly propagated by means of spores and also in other ways, which do not concern us here. There is a very close relation between these organisms and the various other factors, such as the condition of the air, soil, etc., already discussed. In other words, the growth and development of the fungous parasites are intimately related to the condition of the host, which is in turn, as we have already seen, materially affected by the weather and by the soil. There are many fungi which under ordinary conditions could

never injure a tree, and yet if by some chance a favorable opportunity is offered they may prove quite destructive. (Fig. 54.) For example, a limb may be blown or cut off, hail may make a bruise, or in other ways wounds may be produced, and in these the spores of certain fungi may lodge and germinate and start decay that could not have been produced in any other way. Trees may succumb to the attacks of fungi only in certain stages of growth. Thus, young conifers are seldom affected by the disease known as canker, because any wound made in the trunk or branches is quickly covered with a coating of resin, which prevents the spores of the canker fungus from developing. When the trees get to be quite old, however, the wounds are not covered with resin and the spores of the canker fungus fall in these places, germinate, and spread into the surrounding tissue, and the tree is killed. On the other hand, the young, tender, rapidly growing tissues are more susceptible to the attacks of certain fungi than those older and better matured. With these introductory remarks, we may now pass to some of the diseases in detail.


FIG. 54.—Trunk of maple showing spread of fungous mycelium.

ROOT DISEASES.

In considering any case where fungi are found attacking the roots the importance of the previous effects of soil conditions must not be overlooked. An injury or a weakened condition produced by any of the means already pointed out may permit the entrance and development of some disease-producing fungus which might not otherwise gain entrance or find suitable conditions for development. On the other hand, there are fungi which, while they are better able to develop under these conditions, are nevertheless able to gain entrance into and kill what appear to be perfectly healthy roots.

SOUTHERN ROOT ROT.—This disease, which is produced by a fungus known as *Ozonium auricomum*, attacks a great variety of trees and other plants, including the elm, basswood, oak, cottonwood, mesquite, china tree, mulberry, etc. It also attacks cotton and the sweet potato—in fact, no plant appears to escape except the plum and some closely allied groups.

The disease first becomes apparent by the sudden wilting of the leaves, and soon the death of the tree follows. Examination of the tap-root and many of the other roots shows them to be dead and partly rotten, and thus unable to furnish the top with water or food. Trees growing in well-drained and well-aerated soils are seldom attacked, while those in soils very retentive of moisture are the first to succumb. The disease is confined largely to the Southern and Southwestern States, and is especially bad in wet seasons and where excessive amounts of water are used in irrigation. If the roots are examined closely, a whitish or usually yellowish-brown growth of loosely interwoven, hair-like threads will be seen on the surface and in the decaying tissues. These are not confined to decaying parts, but attack apparently healthy roots. Once inside, the fungus spreads rapidly through the cortex and wood, killing the cells and causing their decay. Only the mycelium, or plant body, is known, and this is reproduced from branches or pieces which may be broken or washed off. It has been observed growing in decaying vegetable material taken from the side of an irrigating ditch which furnished water for pears, cottonwood, alfalfa, and other plants dying from the disease. It is probable, therefore, that it may sometimes be distributed in this way. It spreads along roots and decaying material from plant to plant through the soil, and its distribution may also be hastened by tools used in cultivation.

Treatment.—It is seldom that a plant once attacked can be saved, as the trouble is not apparent until the root system is nearly destroyed. If there is any reason to fear this disease, trees should not be set on recently cleared land until the roots of the original vegetation have rotted and the soil is cleared of sticks, limbs, etc. If the trouble appears, the diseased trees should be removed, with as much of the root system as possible, and the roots burned; or it is still better to cut the tree down, leaving a stump 1 or 2 feet high, and then remove the earth about the roots and allow them to dry out. When dry enough the stump should be burned in its original position. Most of the fungus will in this way be burned and that in the neighboring soil killed. Every precaution should be taken to keep the soil well drained, well aerated, and free from weeds.

HONEY MUSHROOM (*Agaricus melleus*).—Another form of root rot is produced by the mycelium of the honey Agaric, or mushroom. The general appearance of the diseased plant is much the same as when attacked by the Southern root rot. Young trees may be killed within a year, but older ones show a weakened, stunted growth, and finally, after several years, dry up suddenly and die when a hot, dry spell comes on. Upon examination the bark at the base of the trunk and on the larger roots will be found to be dead. If a portion of it is removed, a white, leathery growth will be seen between the bark and the wood and between the different layers of bark. It may often be taken out in large sheets of varying thickness. The same will be found between the cortex and wood of the roots. On the outside of

the roots and in the surrounding earth dark-brown strands, varying in thickness from one twenty-fifth to one-twelfth of an inch, will be found. These may in many cases be traced to the white mycelium between the bark and wood. It is simply the mycelium growing in a different form, as it is not subjected to pressure between the bark and wood. These Rhizomorphs, as they are called, spread a few inches under the surface of the ground from tree to tree, and thus large areas may become diseased from a single center. In the autumn, from the base of the diseased tree and from exposed roots and Rhizomorphs, the fruiting bodies of this fungus develop. They are yellowish-brown, and are from 3 to 8 inches high and 2 to 4 inches across the top.

Treatment.—When once a tree is attacked by the fungus, there is no hope of saving it. If the tree is one of a group, it should be isolated by digging a ditch around it. The ditch should be dug deep and wide enough to get beyond the point where the brown strands of the fungus have reached. This precaution will be necessary only with the pines and allied trees, as others are not usually attacked unless first injured.

POLYPORUS VERSICOLOR.—There is good evidence that this fungus, which is a very common one, may produce root rot in many trees. It is probable, however, that such trees have been previously weakened, thus giving the fungus an opportunity to get in. When it occurs on the side of a stump or root, it forms a thin, rigid, shell-shaped growth, extending out at right angles to the surface. Usually many grow together, more or less united to each other at the back. The individual shells vary in size from one-half inch to 2 inches or more in diameter. The concave surface is always down and is made up of a layer of very small pores, in which the spores are produced. This porous surface is usually of a whitish-yellow color. The upper surface is shining, smooth, and velvety, marked with various dull-colored zones. (Fig. 55.)

The mycelium forms a white, felt-like covering on the roots, penetrating and causing the decay of the bark and wood. The first indication of the disease is in the decreased production or stunted growth of the wood and a tendency to overproduction of fruit. Examination of the roots of such trees reveals the white felted fungous strands, which continue to increase in abundance until the roots are nearly all rotted off. It is usually several years from the time a tree is first attacked until its death.

The mycelium spreads from tree to tree along decaying roots, so that in the course of years the trees over large areas are destroyed. Healthy, vigorous trees, in good soil, are much less liable to succumb than those growing under less favorable conditions. Trees planted in soil which has been recently cleared are most liable to attack, first, because the fungus is abundant in the decaying roots, and, second, for the reason that after a few years the nitrogen becomes greatly decreased, as explained elsewhere. The trees which have up to this

time been highly fed and growing vigorously are checked by the decrease of soil food. If this is not at once remedied by fertilization

FIG. 55.—Root-rot fungus (*Polyporus versicolor*).

and cultivation of the soil, the fungus may gain a foothold and the tree is doomed.

Treatment.—In all cases the rapid changes in soil conditions which follow clearing should be guarded against by not planting until these changes have taken place and until the roots of the original vegetation have rotted and proper soil conditions have been established. If injuries occur on the larger roots or the base of the trunk, the places should be cleaned and coated with pitch or coal tar. Burning the stumps and roots of diseased trees where they stand is advisable if the conditions are favorable for the spread of the fungus. In the early stages of the disease the tree may often be saved and enabled to outgrow the trouble by removing the earth from the base of the trunk and larger roots, clearing them as thoroughly as possible of diseased tissue, and applying coal tar to the wounds.

DISEASES OF THE TRUNK AND BRANCHES.

RED ROT OF OAK (*Polyporus sulphureus*).—This disease is most common in oak, but it is also found in the chestnut, poplar, cherry, and willow. Hartig describes it as parasitic also in locust, alder, walnut, and pear. As a parasite it gains entrance to the body of the tree through some wound. The mycelium then spreads through the wood, causing it to dry, shrink, crack, and turn reddish brown. In the cracks the mycelium forms large sheets or felted masses, as in the case of the red rot of the fir and pine. The inside of a trunk may become completely rotten in a few years from this cause. Whenever any wound permits the mycelium of the fungus to come to the surface, a large group of fruits are produced, extending out from the tree like brackets. The under surface is made up of a layer of thin-walled pores, whitish at first, then sulphur-yellow. The top is a whitish-yellow. The brackets are irregular in shape and size and are usually all grown together in an inseparable mass, which is usually from 6 to 20 inches or more across and from 2 to 4 inches thick. (Fig. 56.)

FIG. 56.—Fungus causing red rot of oak.

Treatment.—As the fungus can not gain entrance except through a wound, it may be readily guarded against by properly caring for wounds, as suggested in other parts of this article.

WHITE ROT OF OAK.—This disease is produced by *Polyporus igniarius*, a common fungus, which sometimes attacks the oak, hickory,

willow, and other trees. The mycelium of the fungus grows through the wood, reducing it to a yellowish-white, spongy condition. The Polyporus itself develops on the surface of the bark or wood. It is at first spherical in shape, but later assumes the form of a hoof, with the flat side turned down.

Treatment.—The fungus seldom, if ever, attacks sound tissues, hence the proper care of wounds is all that is required to preserve trees from its attacks.

There are numerous other fungi closely related to those described which may produce various kinds of rots in growing trees. Nearly all these gain entrance through cuts and wounds, hence the necessity of properly caring for these, especially during summer, when parasitic enemies of all kinds are active.

MISCELLANEOUS FUNGOUS PARASITES OF THE STEMS AND BRANCHES.

The fungi described under the previous heads have for the most part prominent fruit forms. There is another group much less conspicuous, but which sometimes causes considerable injury. This group—the so-called black fungi (Pyrenomycetes)—usually appear as dark-colored pustules on the bark of the stems and branches. The injuries in most cases are local, but in many instances a stem or branch may be completely girdled, and of course serious results will then follow. One of the common members of the group is *Nectria cinnabarina* (fig. 57). It occurs on nearly all kinds of deciduous trees, attacking dead and wounded branches and occasionally wounded roots. The fungus can not kill the living cambium and cortex, but grows rapidly through the wood, causing it to turn black and die, while the cambium and cortex are still sound. The wood in this condition, however, is unable to conduct water, so that the parts dependent on it dry up and die.

FIG. 57.—*Nectria cinnabarina.*

Another species, *Nectria ditissima*, with bright red fruiting warts, also attacks a great variety of deciduous plants. It spreads very slowly, however (not more than 1 or 2 inches in a year). The invaded tissue rots, but the surrounding healthy parts increase in growth, so that the part of the branch around the wound may become greatly distorted and swollen, producing what is ordinarily known as a canker spot. *Nectria cucurbitula* causes a similar canker disease of conifers, especially the spruce.

Various other canker-producing fungi attack trees, but it is not necessary to enter into detailed descriptions of them here.

Another class of fungi, belonging to the group of rusts, frequently cause considerable injury to trees, especially conifers. The Peridermiums are probably the most destructive of these parasites, attacking stems, branches, and leaves, and causing various knots, swellings, and blister-like patches.

Treatment.—From the nature of the fungi just considered, it will be seen that about the only means of checking them is to cut out and destroy the diseased parts as soon as possible. In many cases the injuries to trunks and branches are of such a nature that the diseased parts can be removed without trouble. This should be done, and all wounds thus made should be carefully covered with tar or grafting wax.

FUNGOUS DISEASES OF THE LEAVES.

In common with other plants, the leaves of shade and ornamental trees are subject to the attacks of many forms of fungi. Some of these produce local injuries, while others so affect the leaves as to cause them to fall prematurely. In all cases where the leaves are affected it will be seen that the more they are injured the more serious the results to the tree as a whole, for the leaves are the laboratories in which the food is prepared, and any check or injury to them results in a check to the growth of the tree. Probably the most common fungous parasites of the foliage of trees are those producing various kinds of spot diseases. Maples, chestnuts, oaks, basswoods, sycamores, poplars, and various other trees are more or less subject to the maladies in question. These spots are produced by certain species of fungi, which attack the tissues, and by their action first weaken and then destroy them. The spots vary in color, size, and shape, and can usually be distinguished from those brought on by sun scald and similar agencies only by microscopic studies.

Of the other diseases of the foliage, the powdery mildews and rusts are probably the most common. The former attack many trees and shrubs, producing a whitish, spider-web-like growth on the surface. A common example of this group of fungi is found in the mildew which occurs in late summer on the lilac. Maple leaves are also frequently attacked, and the same is true of the chestnut, willow, and other trees. The rusts are limited to a comparatively few groups of trees, among which may be mentioned the pines, poplars, and willows.

Treatment.—There is comparatively little that can be done toward checking these diseases. Spraying in many cases is not practicable on account of the size of the trees, and even if it were, it is questionable whether the injury resulting from the parasites is sufficient, except in some few cases, to pay for the trouble involved. As many of the fungi pass the winter either in or on the old leaves, burning these in the autumn may help materially in keeping the parasites in check. Careful attention to the needs of the trees in the matter of food and water will also go far toward freeing them from the attacks of such enemies as have been described.

SOME MODERN DISINFECTANTS.

By E. A. DE SCHWEINITZ, PH. D., M. D.,
Chief of Biochemic Division, Bureau of Animal Industry, U. S. Department of Agriculture.

THE NATURE OF DISINFECTION.

As the health of man is so largely dependent on the health of animals, and the spread of nearly all diseases among men and animals is susceptible of control if proper methods of combatting the contagion are followed, it is a matter of considerable importance to understand where the dangers of infection lie and what are the best methods of destroying their cause. This process we call disinfection.

The primary cause of all diseases being recognized to be a bacterium, or sometimes a parasite, the source of infection may be removed by destroying the parasites or germs. Bacteria, in multiplying either inside or outside the animal body, often form compounds, frequently gases, that are exceedingly disagreeable, so that these dangerous enemies are often easily recognized. Different substances may be used to counteract these disagreeable odors, and it is sometimes thought that by destroying the noxious odors all danger has been removed. This, however, is not the case, as many substances will act as deodorizers which are not germ destroyers. Again, we have other substances which will retard the action of germs and prevent their multiplication, but will not kill them, while a true disinfectant destroys the germs, counteracts and destroys the disagreeable odors resulting from decomposition, and hence prevents danger of further spread of disease. It is to this latter class of substances, especially modern disinfectants, that attention will be called in this article, and the comparative merits of some of them, as developed by their use, will be pointed out.

THE MERITS OF SOME DISINFECTANTS.

STEAM AND BOILING WATER.

The best disinfectants, where they can be applied, are steam and boiling water. There are some practical objections to them, however, on account of the difficulty of always obtaining them in a convenient place, and the injury to the walls of a room, articles of furniture, bedding, clothing, etc., resulting from their use. Hence, disinfectants which are more conveniently applied and do not injure materials with which they are brought into contact are preferable.

CARBOLIC ACID.

Though many new disinfectants have been recommended in its place, carbolic acid, so long known, has retained its position as one of the best disinfectants in surgical work, as well as for general purposes, when there are no practical objections to its use. In solutions varying from one-half of 1 per cent to 5 per cent in strength, it is a valuable destroyer of all disease germs. For disinfecting stables, barns, outhouses, fæces, expectorations, etc., a 5 per cent solution should be used. Its odor and poisonous properties are sometimes objectionable. Küppe and Laplace found that crude carbolic acid when treated with sulphuric acid gave a product the disinfectant properties of which were increased with an admixture of cold water, but diminished in warm water. If this mixture is to be used, it should be prepared by stirring the sulphuric acid slowly into the carbolic acid with a wooden paddle in a wooden or iron receptacle. Fränkel found that when crude carbolic acid was distilled it yielded a product boiling between 185° and 205°, which in a 5 per cent solution killed anthrax spores (among the most difficult to destroy) in twenty-four hours. Treated with sulphuric acid, the cold solutions again showed stronger disinfecting properties than the warm, which was supposed to be due to the fact that the sulpho-acids formed had weaker properties as disinfectants.

SUBSTITUTES FOR CARBOLIC ACID.

Subsequently, others succeeded in dissolving cresols, crude carbolic acid, etc., in various soap solutions which could be substituted for the more expensive pure carbolic acid. A number of such products as creolin, lysol, cresolin, cresin, etc., were offered as substitutes for carbolic acid, all being solutions in resin soap of the cresols and similar hydrocarbons. These preparations behaved differently when dissolved in water. Some gave clear solutions, others milky solutions, due to a partial decomposition of the compounds. An effort was then made to discover a substance which would dissolve these materials more readily and always give a clear solution. It was found that salicylate of sodium or some of its derivatives formed suitable menstrua, and the name solveol was given to a number of such preparations.

Many articles have been written upon the action of these materials of various origin, showing that all had about the same value. A pure preparation of the cresols, a mixture of ortho, meta, and para cresol, was also put on the market under the name tricresol. It was found that this tricresol was about as soluble in water as carbolic acid, had three times its efficiency, and only one-third its poisonous properties.

One of the preparations mentioned above, viz, creolin, is composed very largely of hydrocarbons, which are with difficulty soluble; it yields on the addition of water an emulsion. Sirena and Misuraca treated tuberculous material, such as sputum, with a 3 per cent to 5

per cent solution of this substance one to two days and could notice no destruction of the germs. Tried upon anthrax bacilli and spores, its antiseptic properties were not marked.

A great many results where lysol has been used have been reported. Gerlach, who studied the subject thoroughly, concluded that lysol is more active than carbolic acid and creolin, and that disinfection of the hands is possible with a 1 per cent lysol solution; it is said to be more serviceable than any other agent in disinfecting sputa and fæces. A 3 per cent solution, used as a spray upon the walls, will make them germ free, and as compared with carbolic acid, sublimate, and creolin it is much less poisonous.

Of the many other disinfectants (a large number of which are derivatives of those already referred to), the majority, as aseptol, europhen, and the like, are more especially intended for medical and surgical use, and are either too expensive or for some other reason, such as difficulty of solubility, not adapted to household use or for purposes of general disinfection.

FORMALDEHYDE.

For many reasons, the best results in disinfecting rooms or buildings can be secured by means of a gaseous disinfectant which will readily penetrate to all parts of a building and impregnate articles, such as upholstery, bedding, and the like, without injuring them. Sulphur dioxide was for a long time the least injurious gaseous disinfectant known, but within a few years formaldehyde gas, or its solution in water, has begun to replace the other gaseous disinfectants. Though irritating to the mucous membrane, it is not nearly so disagreeable as sulphur dioxide; it is not as poisonous, nor is it injurious to metals, wood, or fabrics.

In order that a disinfectant shall be thoroughly satisfactory, certain conditions must be fulfilled. In the first place, it should destroy surely and quickly the most resistant forms and spores of injurious bacteria. It must be a substance that can be easily used, and be nontoxic and nondestructive to mineral or vegetable matters in the concentration necessary to insure complete disinfection. Further, it should be a substance which can be applied in a gaseous condition, to secure thorough contact and penetration of the objects to be disinfected. Again, it must be a substance which is stable in character, not easily decomposed, cheap, if possible possessing an odor which dissipates quickly, and a good deodorizer. To a certain degree formaldehyde possesses all these properties, and its practical use has been the subject of a number of investigations. Commercially, we find formaldehyde in the market as a 40 per cent solution of the gas in water or wood alcohol under the trade names of formalin and formol. The formaldehyde gas and its solutions can be prepared with great

case by the partial oxidation of wood alcohol. As early as 1888 the strong antiseptic properties of formaldehyde were recognized by Low, and in 1892 Trillat published the statement that a bouillon containing 1: 50,000 of formaldehyde was not suitable for the growth of the anthrax germ. Aronson, after making similar experiments, tried the poisonous properties of the gas upon guinea pigs, and found that they could live for an hour in an atmosphere rich in formaldehyde gas. During this experiment the animals were very restless, but recovered very quickly in normal air. Zuntz had already shown that the poisonous dose for rabbits after a subcutaneous injection was about 0.24 gram per kilo.

In 1893 formaldehyde was recommended for the disinfection of brushes and combs, as well as for use to destroy the germs of diphtheria, tuberculosis, cholera, and the like on such materials as would be injured by other disinfectants.

Another authority asserted in 1893 that after one hour in solution of 1:10,000 and after fifteen minutes in 1:750 anthrax and tetanus germs were destroyed. The results further showed that in the air 2.5 per cent by volume of formalin, or 1 per cent by volume of formaldehyde gas, was sufficient to destroy fresh virulent cultures of typhoid, cholera, anthrax, etc., in fifteen minutes. Other experiments have shown that bandages and iodoform gauze can be kept well sterilized by placing in the jars containing them some formaliths, a solid preparation containing formaldehyde, and it was also possible for Stahl to make carpets and cloth materials germ free by spraying them with 0.5 to 2 per cent formalin solution for fifteen to thirty minutes without the color of the carpet being in any way affected. The researches of Pottevin in 1894 confirmed those of Aronson and Trillat that a concentration of 1:20,000 was safely a retardent of sufficient strength.

In 1894 the deodorizing property of formaldehyde was explained to consist in a direct chemical combination of formaldehyde and sulphureted hydrogen, or with ammonium compounds and their derivatives present in fæces, decomposing animal matter, and the like. With scatol, one of the odorous constituents of the fæces, formaldehyde combines upon the addition of acid to an odorless compound.

As Walters has shown, so far as the action of formaldehyde in gaseous form is concerned, that is dependent upon the concentration of the gas, the temperature, and whether the articles to be disinfected are moist or dry. The killing of the germs appears to be better accomplished when the objects are very slightly moist (not wet), and the temperature is 35°. This is a property which has long been well known as belonging to sulphur dioxide, chlorine, and bromine.

Of the practical methods of applying formaldehyde, those in which the gas is allowed to work in statu nascendi have given the best results. Several forms of lamps have been devised in which the formaldehyde is obtained by the imperfect combustion of methyl alcohol.

These have the advantage that the lamp can be filled and placed in the room or other closed place which it is desired to disinfect. They have the disadvantage, however, that some of the alcohol suffers complete combustion, that a certain amount of carbon monoxide and dioxide are also obtained, and that a little alcohol is lost and consequently a larger amount of alcohol is used than should be necessary. Practical experiments made by Miguel, Bardet, Trillat, and others in disinfecting rooms by means of these lamps have given very satisfactory results. The principle of the lamp is to allow the flame to burn over a wire mantle of platinum or a platinized asbestus wick.

Two simple lamps for this purpose may be described here, the one designed by Professor Robinson, of Bowdoin College, the other by the writer. The latter can be readily understood from the accompanying illustration (fig. 58), the point being the use of a wick in whole or in part of platinized asbestus. The lamp is filled with alcohol, and the wick turned up slightly and lighted in the ordinary way. After a minute the asbestus portion of the wick becomes heated to such a temperature that the platinum distributed over the surface will continue to glow and convert alcohol into aldehyde as long as the lamp remains filled. Professor Robinson's lamp is described by himself as follows:

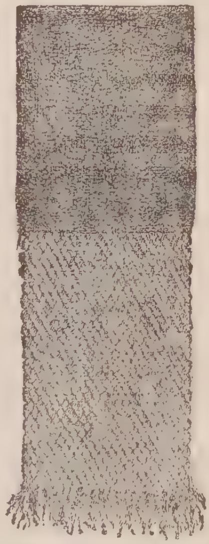

FIG. 58.—Wick for formaldehyde lamp.

I take a disk of moderately thick asbestus board and have it perforated with small holes close together. This is then platinized in the usual way, using quite a strong solution of platinic chloride. If now a shallow dish, cylindrically formed and of such size that the perforated asbestus disk will just cover its top, be partly filled with methyl alcohol, it serves as the lamp font. If the platinized disk be wet with alcohol, seized in a pair of forceps or small tongs, removed from the dish, and the alcohol lighted, it will, by the time its alcohol burns away, be heated sufficiently so that when placed over the lamp font again it will continue hot and change the alcohol to aldehyde. Experience shows that with proper depth of dish and suitable holes for admission of air, the disk keeps of a proper redness to bring about the change most efficiently. The gas may also be applied by warming its solutions and better exhausting the air in a closed vessel containing formalin. If this solution is heated, some of the formaldehyde is polymerized and converted into an inactive form.

The use of formaldehyde for the purpose of destroying the spores of smut by the action of 1:10,000 formalin solution has been recommended. In all experiments in using this material, attention must be paid to the fact whether reference is made to the formalin solution or to formaldehyde gas. It is probable that with a convenient method of generating the gas this might be used to advantage in destroying insects injurious to vegetation.

Walter has carried out a series of experiments with formalin and also with the gas which can be obtained from it. His experiments

were made first by preparing different kinds of culture media to which formalin had been added in different proportions. The results of these tests upon anthrax spores, cholera, typhus, and diphtheria germs showed that the proportion of 1:10,000 or 1:20,000 of formalin, or 1:25,000 of formaldehyde gas, is sufficient to check the growth of the germs. When the gas is used, the *Staphylococcus pyogenes aureus* seems to be the most resistant, while, strange as it may appear, the spores of anthrax, so difficult to kill by most germicides, are very easily destroyed by formalin. This is one of the principles laid down by Koch that some substances would be found which were destructive to pathogenic bacteria, but were less injurious to ordinary germs.

In order to prove the value of formalin on a large scale for the disinfection of clothing, Walter used a soldier's blue mixed with red color, which he immersed in a culture of the pure germ, so that the cloth was thoroughly saturated. Strips were then cut off, placed under a bell jar, and sprayed with formalin solution varying in strength from 3 per cent to 10 per cent. The strips were left in the bell jar six hours. After that time tests were made by cultures from these strips, check strips being used at the same time. There was no change produced in the color of the cloth, and the red was, if anything, a little brighter. The germs which had penetrated deeply into the cloth were all killed, just as were those upon the surface. This can be explained probably by the fact that the articles being surrounded with the jar the gas was forced deeply into the interstices of the cloth and killed those germs which could not be reached by the solution. The 3 per cent solution gave just as satisfactory results as the stronger solutions.

The preliminary experiments that Walter made with the gas to prove the availability of formaldehyde for the disinfection of clothing, etc., without injury to the latter were satisfactory except with reference to the length of time required. This, however, was due to the practical details of the method, as the source of the formaldehyde was either the powder placed under a bell jar or a lamp used in a room which was poorly adapted to the purpose, there being too many openings for the escape of the gas.

SUMMARY.

The results of all investigations have led to the following conclusions:

1. Formalin in concentration, 1:10,000, makes the growth of tuberculosis, anthrax, cholera, typhus, pus, and diphtheria germs impossible.
2. In gaseous form a weak dilution is sufficient to check growth.
3. A 1 per cent solution will kill pathogenic organisms in an hour.
4. With a 3 per cent solution and the final addition of alcohol it is possible to make the hands germ free. Whether the skin of the hands is attacked by this method remains to be proved.

5. Spraying with formalin solution and subsequent inclosure of the articles in a closed space will easily sterilize them.

6. Uniforms, etc., can be disinfected on a large scale without injury, twenty-four hours being required.

7. Fæces are deodorized by a 1 per cent solution, and are in thirteen minutes germ free; and buildings can be readily disinfected by a 1 per cent to 1.5 per cent volume of the gas.

8. Formaldehyde is a useful etching material and preservative.

As compared with other disinfectants, such as corrosive sublimate, carbolic acid, lysol, etc., formaldehyde and its solutions have the advantage of not being retarded in their action by albuminoid matter and of not injuring the articles to which they are applied. Their use therefore seems to be well recommended and to fill many requirements which are not now fully met by other disinfectants. Especially is this the case in disinfecting rooms, clothing, bedding, railroad cars, etc.

Experiments made by Roux, Trillat, and others upon the use of formaldehyde vapor for disinfecting rooms have been very satisfactory, in that the bacilli of anthrax, tuberculosis, and diphtheria have been killed within five hours by a saturated atmosphere of formaldehyde gas. After two days of thorough ventilation no odor remained in the room, nor were the objects which had been exposed to the action of the gas in any way injured. An objection to the use of formaldehyde has been raised because it adheres somewhat tenaciously to clothing and upholstered materials and the odor dissipates slowly. This, however, can be removed by thorough ventilation or by the use of a dilute solution of ammonia, which readily absorbs the gas. Placed in a room where formaldehyde has been used as a disinfectant, this would aid in a more rapid dissipation of the odor and not injure the materials. It would seem that in formaldehyde we have at hand the most useful disinfectant yet known, the application of which is a mere detail to be easily worked out in practice.

It also appears to be useful as a means of preserving food, milk, etc. Its effect upon the digestive ferments has not been thoroughly studied, but the quantity used for preserving milk, 1 part to 10,000, should be too small to give rise to any bad result, and none has been noted in practical use. Its influence in this connection should be carefully studied before it is generally recommended.

While testing the action of this gas upon the cattle tick recently, its action upon the respiratory organs of cattle was noted. A calf was kept for five hours in an atmosphere containing about 2 per cent of formaldehyde gas. During this time there was a slight watering from the eyes and it coughed occasionally, but it did not seem to be in any special distress, and as soon as it was brought into the fresh air again it was all right and showed no bad after effects. This fact may prove of importance in disinfecting stables and the like.

Another direction in which formaldehyde promises to be of practical importance is in the disinfection of imported hides, which may carry contagion, especially anthrax. The rapid action and penetrating power of this gas bids fair to overcome the practical difficulties hitherto attending the use of disinfectants for this purpose.

In regard to the use of formaldehyde, it is of importance to know the percentage of gas which will be necessary to disinfect a room of given size and what percentage should be used in any given disease. If the alcohol used is entirely converted into aldehyde by the lamps, as indicated, 1 liter of pure wood alcohol will give 748 grams of aldehyde = 361 liters of this gas. The capacity of a room of 1,000 cubic feet is 28,684 liters, so the above quantity of alcohol would give 1.26 per cent aldehyde in a room of this size.

Experiments have shown that very much less than 1 per cent by volume of this is destructive to injurious bacteria, but an atmosphere containing 1 to 1.5 per cent by volume will give satisfactory results in six to thirteen hours in all cases. When the volume of the gas is increased, the length of time necessary for the disinfection is considerably decreased.

Of the mineral salts recommended as disinfectants in the solid form, many are deodorizers and not true disinfectants. Others, like corrosive sublimate, are too poisonous, or can not be used with good effect in presence of albuminoid matter. One should always remember the difference between destroying the cause of infection, the only safeguard, and simply removing disagreeable odors.

Boiling water and steam are excellent disinfectants when they can be applied, but best of all for general disinfection are formaldehyde gas and its solutions.

It should be noted that a 40 per cent solution of formaldehyde gas can be purchased for one-fourth the price paid for formalin, which is exactly the same thing.

MIGRATION OF WEEDS.

By Lyster H. Dewey,
Assistant in Division of Botany, U. S. Department of Agriculture.

GENERAL REMARKS.

A large proportion of the plants growing along roadsides, on waste ground, and in plowed fields in the older cultivated parts of this country are migratory weeds. They were not native where they are now found, but have appeared since the introduction of cultivation. They have come from other countries, or from other places in this country, and their offspring, in turn, is likely to be disseminated still further. A migratory weed is a plant which is continually spreading to new areas, and which there increases to such an extent as to be injurious.

The methods of weed migration fall into two classes, the natural, in which the dissemination is unaided by man, and the artificial, including the many ways in which the distribution is somehow furthered by human agency.

Fig. 59.—Orange hawkweed: *a*, runners; *b*, akene, or "seed"—natural size and enlarged.

WEED MIGRATION BY NATURAL MEANS.

Natural methods are all those in which the dispersion is accomplished through the powers of the plant itself cooperating with its environment exclusive of human agency. Natural methods in turn subdivide into two classes according as the dispersion is not or is aided by some external locomotive agent, as wind or water.

RUNNERS.

Among the methods of the first class is spreading by runners, that is, by slender radiating branches, producing plantlets at the nodes, which take root in the ground. Cinquefoil (*Potentilla canadensis*) is a typical example of this class, with runners extending 10 to 30 inches

from the parent plant. Bermuda grass (*Capriola dactylon*), north of the Gulf States, spreads almost exclusively by runners, as it rarely produces seeds in cooler latitudes. Its runners often grow 8 or 10 feet in a single season, enabling it quickly to cover with a beautiful green either the front lawn or the vegetable garden. Orange hawkweed (*Hieracium aurantiacum*) (fig. 59) produces numerous runners 6 to 15 inches long. Though comparatively short, they enable the plant to multiply and form dense patches to the exclusion of other vegetation.

ROOTSTOCKS.

A common independent method of spreading is by underground stems, called rootstocks, or rhizomes. These run along below the reach of the mowing machine or of grazing animals, and often too deep to be disturbed by surface cultivation. They produce buds at their numerous scaly nodes, and these buds develop into new plants in exactly the same manner as branches are produced above ground. St. John's wort, sorrel, ramsted, perennial ragweed, and eagle fern all have rootstocks from 10 to 50 inches long, enabling them to spread short distances. Among the most notable examples of rootstocks are those of couch grass (*Agropyron repens*) (fig. 60) and Johnson grass (*Sorghum halepense*), which often grow to a length of 10 to 15 feet in one season, furnishing these grasses with a means of rapid distribution and propagation, a character making them at once most valuable in the pasture and meadow and most pernicious in cultivated fields.

FIG. 60.—Couch grass, showing rootstocks.

RUNNING ROOTS.

Some of the weeds which are most difficult to eradicate are propagated from running roots. Such are Canada thistle (*Carduus arvensis*) (fig. 61), horse nettle (*Solanum carolinense*), milkweed (*Asclepias syriaca*), and showy spurge (*Euphorbia corollata*). These roots often branch and form a complete network extending horizontally at a depth of 6 to 30 inches below the surface of the ground. They have no nodes, scales, or apparent buds. The absence of these

organs distinguishes them from rootstocks, or rhizomes. They are capable of producing shoots at almost any point. Prof. A. N. Prentiss, of Cornell University, demonstrated by experiment that a Canada thistle root cut into pieces one-fourth of an inch long can produce shoots from nearly every piece. Pulling up plants which spring from running roots rarely injures the root system. The plant pulled up usually breaks off at the point where it is attached to the horizontal root, leaving the latter undisturbed. The horizontal root system is often below the reach of the plow, and while the farmer is industriously mowing, pulling, and cultivating to destroy the plants which appear above ground the root system remains uninjured except for the loss of nourishment, and continues to send up new shoots which will grow as soon as the cultivation is relaxed. In fact, the only practicable methods of killing roots of this class are to starve or exhaust them by preventing the growth of any shoots above ground during several successive years and to poison them with kerosene, brine, or acids, or other chemicals.

FIG. 61.—Canada thistle: *a*, running root; *b*, akene, or "seed;" *c*, akene enlarged, showing how the pappus, or "thistle-down," is detached.

SEED-THROWING APPARATUS.

One of the most interesting yet least known methods by which plants travel short distances is by throwing their seeds. When the pods of the common tare (*Vicia sativa*) (fig. 62, *a*) are mature, they dry in such a manner as to produce a strong oblique tension on the two valves or sides of the pod. The valves finally split apart and curl spirally with such a sudden movement as to throw the "peas" several feet. In many of the species of spurge (*Euphorbia*) the seeds are tightly pressed by the sides of the ripening capsule, and they are finally expelled with considerable force in much the same manner as a lemon seed is thrown by pressing it between the thumb and finger. The seeds of wood sorrel (*Oxalis stricta*) are packed in rows in the small, erect, green pods (fig. 62, *b*). Each seed is surrounded by a very elastic transparent covering, and as it ripens and forces its way out through the opening at the side of the pod this covering splits down one side and turns inside out with a force that is often sufficient to throw the seed several feet (fig. 62, *d*, *e*). The small-flowered geranium (*Geranium pusillum*) has each one of its five seeds fastened

to a separate section of the flower style. When the seed ripens, these sections of the style become dry and develop into strong springs, which break away at the bottom and by curving upward throw the seeds (fig. 62, *f*, *g*).

While by this class of methods plants are able to travel only comparatively short distances, they are, on the other hand, enabled completely to cover infested areas, and when once established are not easily removed.

In the second class of natural methods of dissemination the plant avails itself in some way of natural locomotive agencies external to itself. There are three such agencies which aid very much in the migration of weeds. These are wind, water, and animals, the most important being the wind.

FLYING SEEDS.

Many weed seeds have special adaptations, enabling them to be carried through the air by the wind. Dandelion (*Taraxacum taraxacum*) (fig. 63, *a*, *b*), prickly lettuce (*Lactuca scariola*), Canada thistle (*Carduus arvensis*) (fig. 61, *b*, *c*), horse weed (*Erigeron canadensis*), and many other seeds, or akenes, of the composite family have a feathery down, or pappus. The seeds of milkweed (*Asclepias*) (fig. 63, *c*), dogbane (*Apocynum*), and willow herb (*Epilobium*) are each provided with a tuft of hairs or coma. Penny cress (*Thlaspi arvense*) (fig. 63, *d*) has a winged pod inclosing the seeds, and drop-seed dock (*Rumex hastatulus*) a winged calyx. Broom sedge (*Andropogon virginicus*) (fig. 63, *e*, *f*, *g*) has hairs upon the flower stems and upon the glumes surrounding the seeds. These examples illustrate the principal adaptations by which the seeds of weeds in this country are borne upon the wind. The winged seeds of the rock cress, the keyed fruits of the

FIG. 62.—Seed-throwing by plants: *a*, pod of common tare; *b*, pods of wood sorrel; *c*, transverse section of pod enlarged; *d*, outer seed-coat turned inside out; *e*, seed thrown from the outer coat; *f*, mature fruit of small-flowered geranium; *g*, same enlarged.

maple and elm, and the downy fruits of the willows and poplars are examples of special adaptations for distribution by the wind, but these plants are not classed among our troublesome weeds.

The distance which this class of seeds may be carried by the wind may easily be exaggerated, being ordinarily not more than 2 or 3 miles, or in hurricanes perhaps 10 or 15. There are no well authenticated accounts of seeds traveling long distances in this manner. The seeds of dandelion, Canada thistle, and milkweed are all very easily detached from their downy parachutes, and when the latter are seen floating about on light breezes one may be reasonably certain that their seeds are already gone.

The proportion of our really troublesome weeds of which the seeds have adaptations for flight is small, being less than 10 per cent. Of the weeds which have spread with remarkable rapidity during the past ten years, only the prickly lettuce and the orange hawkweed dif-

FIG. 63.—Seeds carried by the wind: *a*, dandelion, akene with stalked pappus; *b*, same enlarged, stalk broken; *c*, milkweed seed with coma; *d*, winged pod of penny cress; *e*, panicle of broom sedge; *f*, spikelets detached; *g*, spikelet enlarged.

fuse their seeds in this way. It is further true that few of the annual species of this class, which have no means of propagation but their seed, take exclusive possession of the ground, as do the annual ragweeds, dog fennel, and marsh elder, the seeds of which fall near the parent plant. On the other hand, none of the pappus-bearing weeds are more thoroughly distributed over large areas than are buttonweed, pigeon grass, crab grass, and other weeds, which appear to have no special means of distribution.

DRIFTING OVER FROZEN GROUND OR SNOW.

A partial explanation of the distribution of many of our most common weeds lies in the fact that their seeds are blown over the frozen ground or over the snow. Of this class are ragweed (*Ambrosia artemisiæfolia*), giant ragweed (*Ambrosia trifida*), buttonweed (*Diodia teres*),

and barnyard grass (*Panicum crus-galli*). Their seeds are produced late in the season, and some of them are held with such tenacity that they are dislodged only by the strongest winds when the conditions are favorable for their being carried some distance, the ground being frozen or covered with snow. This method of seed dispersion accounts in part for the roadside distribution of ragweed, mayweed, and similar plants which grow between the wagon tracks and the grass along Northern highways. This weed border is less clearly marked in the South, where there is less snow and less frozen ground to offer a smooth pathway for the drifting seed. It also accounts in part for the fact that weeds are distributed much more rapidly over fields left bare during the winter than over those which are covered with some crop which will catch the rolling seeds. In experiments conducted by Prof. H. L. Bolley, Agricultural College, Fargo, N. Dak., wheat grains drifted over snow on a level field 30 rods in one minute with a wind

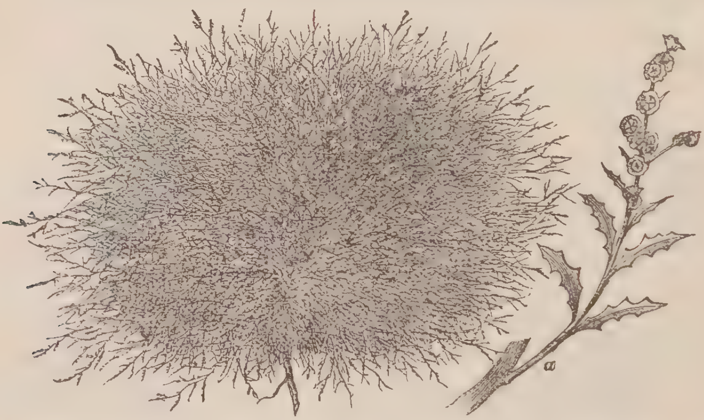

FIG. 64.—Winged pigweed, a typical tumbleweed in form: *a*, small branch with leaves and flowers—natural size.

blowing 25 miles an hour. Lighter or angular grains were found to drift more rapidly. Numerous seeds of barnyard grass, pigeon grass, penny cress, and ragweed were found in drifted snow taken from a frozen pond and from a plowed field, in each case several rods distant from standing weeds.[1]

TUMBLEWEEDS.

The distribution of weed seeds by the plants rolling as tumbleweeds has been particularly brought to notice during the past few years by the Russian thistle (*Salsola kali tragus*), which has furnished a notable illustration of the effectiveness of this method. Tumbleweeds are most numerous and are best developed in the prairie region, where there is little to impede their progress and where there are strong winds to drive them onward. An ideal tumbleweed should be 10 inches or more in diameter, spherical or circular so as to roll well,

[1] Bulletin No. 17, Experiment Station, Fargo, N. Dak.

thickly branched so as to catch the wind, light, yet strong enough to hold together, supplied with abundant seeds clinging to the plant with considerable tenacity so as to drop gradually as the plant travels along, and fitted with some adaptation enabling it to break loose from the ground. One of the best examples of tumbleweed is the winged pigweed (*Cycloloma atriplicifolia*) (fig. 64). In addition to this the following are among the best developed tumbleweeds on the prairies west of the Mississippi River: Tumbleweed (*Amaranthus albus*), low amaranth (*Amaranthus blitoides*), bug seed (*Corispermum hyssopifolium*), and buffalo bur (*Solanum rostratum*). These are all annual plants and all native, as are nearly all our tumbleweeds. Two notable exceptions are Russian thistle and tumbling mustard (*Sisymbrium altissimum*), which have been introduced recently from Europe. But tumbleweeds also abound in the Eastern States, though here they are smaller and less aggressive, and hence attract less attention. They can readily be found by examining open ditches, gullies, or fence corners at any time from midsummer to late in the winter. These will usually be found filled with dried bushy weeds which have not grown there. Prominent among these weeds early in the season is hair grass (*Agrostis scabra*); later we find old witch grass (*Panicum capillare*) (fig. 65), and meadow comb grass (*Eragrostis pectinacea*). After the ground is frozen in the fall the number of species which roll as tumbleweeds increases and many coarser plants are included.

FIG. 65.—Old witch grass: *a*, panicle detached.

The manner of breaking loose is a most important character in tumbleweeds. Most of the tumbling grasses have large spreading panicles which usually become detached by the stalk pulling out of the upper sheath; but in the case of *Schedonnardus texanus* the ball is formed of several plants with curved stems matted together. The coarser tumbleweeds are set free in various ways. Some of those in sandy lands have a rather small root, which is pulled out by the force of the wind. Some are twisted and broken off by the wind after the ground is frozen. Some are attacked by fungi at the base of the main stem, which weakens them so that they break off readily at maturity.

Others are eaten off by insects, and still others are so highly developed in this respect that they form a kind of node and callus, and break off at maturity in practically the same manner as a mature leaf breaks from a tree in the fall.

Efforts have been made to check the progress of tumbleweeds, or at least of the Russian thistle, by building fences. These efforts have been successful only in a very small degree, as the weeds pile up and are blown over the tops of the fences, and also the detached seeds are blown through. It will doubtless be found in practice quite as difficult to check the progress of tumbleweeds as to check the dispersion of seeds by aerial flight or by drifting over the snow or bare ground. In any case the only safe and thoroughly effective method is to destroy the weeds before the seeds reach maturity.

SEEDS CARRIED BY WATER.

Water, next to wind, is the most important natural agent in the distribution of weed seeds. Every dashing rain carries innumerable seeds in the muddy little hillside rivulets it creates. Some of these seeds are likely to be carried on through larger and larger streams until they reach a river. The chances of finding a lodgment suitable for germination and growth are exceedingly small for seeds of highland weeds floating on river currents, but that many of them do germinate and grow we have abundant evidence in the species which appear along the river banks after every freshet. Seeds doubtless make longer journeys in this manner than by any other natural means except ocean currents and migrating birds. Most of the seeds which are carried long distances by the ocean currents are those of maritime plants which are especially adapted for floating and for retaining their germinative vitality in salt water. We have no record of any noxious weeds migrating in this manner.

The distribution of weed seeds by water is of special importance in regions where irrigation is practiced. The Russian thistle was introduced in 1892 near the upper waters of the Arkansas River in Fremont County, Colo. The freshet in this river in the spring of 1894, together with the use of its water for irrigation, scattered the Russian thistle in a single season over many of the farms throughout the valley as far as the eastern line of the State. It has since traveled down the river and infested irrigated lands nearly one-third of the way across the State of Kansas. This plant has also spread extensively in irrigated lands along the Platte River in northern Colorado and along the Snake River in southern Idaho. We should doubtless find a similar record for the cocklebur, giant ragweed, high-water shrub, sunflower, and many other weeds if their histories could be traced in irrigated lands. The banks of irrigating canals and ditches offer exceptional advantages for the growth of highland weeds, and too often these weeds are permitted to ripen seeds which are carried by

the water to all the farms below. Seed dispersion by irrigating water could to a large extent be prevented by destroying the weeds on the banks of the canals, and the question is simply whether this would not be cheaper than fighting the weeds after they have spread over the fields. Plants for binding the soil are needed on canal banks, but the root systems of noxious weeds are rarely of much value for this purpose. The place of the weeds could be well taken by soil-binding grasses that would be harmless in the fields.

SEEDS CARRIED BY ANIMALS.

A third natural means of weed migration lies in the transportation of seeds by animals. The running blackberry, pokeweed, black nightshade, poison ivy, and a few other weeds have berries which are eaten by birds. The hard seeds of these berries pass undigested. The cowbird, red-winged blackbird, sparrows, and other seed-eating birds feed largely upon the seeds of pigeon grass, knotgrass, dandelion, thistles, and ragweed. When these seeds are abundant, the birds sometimes eat more than they can digest, and thus they may carry undigested seeds to new localities. Migrating birds flying at the rate of 100 miles per hour may perhaps carry weed seeds in condition for germination to a distance of several hundred miles, but it is generally supposed that they do not fly long distances with full crops. There are not sufficient data upon which to base a definite statement as to how far weed seeds may be carried in this manner, but it may be safely asserted that the benefits due to the destruction of weed seeds by seed-eating birds outweigh a thousandfold the damage arising from their distribution of the seeds.

The smaller and harder seeds eaten by well-fed cattle and horses usually pass undigested, unless they happen to be crushed by the teeth in chewing the food. In this manner, as these animals wander from field to field or are driven along the road, they doubtless become to some extent responsible for the distribution of nut grass and some of the mustards, dodders, cinquefoils, and plantains. Without artificial aid in transporting hay and grain containing the weed seeds and in carrying the manure from the barns to the fields this method of weed dispersion is of comparatively little consequence. The most important way in which animals, either wild or domesticated, aid in the distribution of weeds is by bearing the seeds on their coats. This is made possible by the hooks which are produced on the seed vessels of a great variety of plants, making them together or singly into burs, "stick-tights," etc. These structures appear in a great variety of forms, of which the following are a few typical examples: The akenes of the tall crowfoot (*Ranunculus acris*) and several other species of the genus *Ranunculus* are enabled to cling by means of their persistent hooked styles. The pods of wild licorice (*Glycyrrhiza lepidota*) (fig. 66, *a*, *b*) are covered with hooked spines. The wild carrot

(*Daucus carota*) produces umbellate clusters of two-seeded fruits, each fruit armed with rows of small barbed hairs. In the composite flower of the Paraguay bur each separate scale of the inner involucre enlarges and becomes hard and spiny, carrying with it a seed, or akene. The involucral scales of Apache bur and creeping bur ragweed (*Gærtneria*) and the cocklebur (*Xanthium*) (fig. 66, *c*, *d*) unite, forming hard spiny burs. In the place of the downy pappus adapting the seeds, or akenes, of the thistle and dandelion for aerial flight, the akenes of bur marigold and beggar's ticks (*Bidens*) (fig. 66, *e*, *f*) have two to four barbed awns, enabling them to adhere to the hair of animals. The burs of the burdock (*Arctium lappa*) (fig. 66, *g*, *h*), which are almost ideal for the purposes of seed distribution, are composed of a ripened head surrounded by involucral scales with attenuate hooked

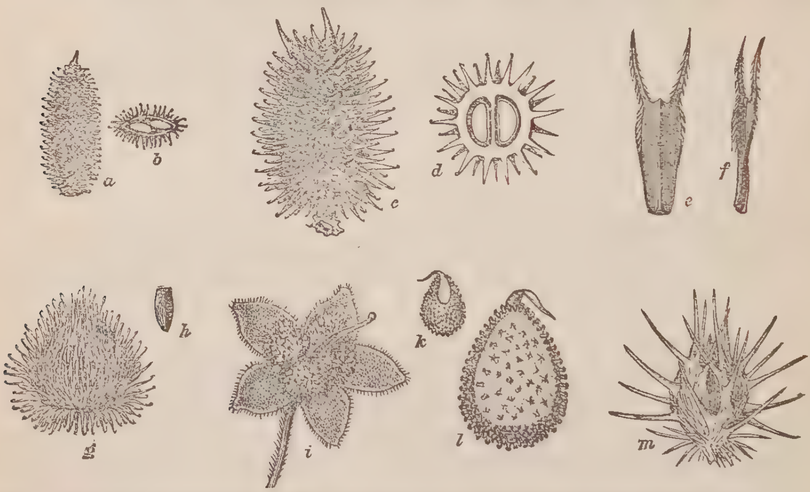

FIG. 66.—Burs and seeds carried by animals: *a*, pod of wild licorice; *b*, transverse section of same; *c*, cocklebur; *d*, transverse section of same; *e*, akene, or "seed," of bur marigold; *f*, same, side-view; *g*, burdock bur; *h*, akene, or "seed," of burdock; *i*, fruit of hound's tongue with four nutlets; *k*, nutlet, natural size; *l*, nutlet, enlarged; *m*, bur of bur grass.

tips. Each bur contains numerous seeds, which are distributed as the bur is carried along. Hound's-tongue (*Cynoglossum officinale*) (fig. 66, *i*, *k*, *l*) and several other species of the borage family have one-seeded nutlets, the surface of each nutlet being covered with short hooked or barbed prickles admirably adapted to cling to the hair of passing animals. The burs of bur grass (*Cenchrus tribuloides*) (fig. 66, *m*) are formed by a hard spiny involucre inclosing the ordinary grass spikelets. The spines of these burs are rigid, minutely barbed, and exceedingly sharp, making them more injurious in wool than the burs of any other species found in North America. Bur grass is native in the Atlantic Coast region, but it has been introduced in nearly all parts of the United States where sheep raising is carried on extensively. The barbed stipes and awns of musky alfilerilla, porcupine grass, squirrel

tail, and red chess furnish means by which the seeds of these plants attach themselves to the coats of animals.

Many species of cacti have detachable spiny fruits and some detachable joints armed with barbed or hooked spines. Cactus plants are not generally regarded as troublesome weeds and the spiny joints are not technically burs, but they perform the office of burs in distributing and propagating the plants, and they cause the same kind of injury to wool and annoyance to animals that are caused by burs. The various methods now considered by which seeds are distributed without human aid are effective over moderate areas, but are inadequate to explain the long and rapid migrations of weeds of which we have such notable examples in recent times. Seeds are rarely carried long distances by any of these methods, and when restricted to them plants make comparatively slow progress. Buffalo bur (*Solanum rostratum*), an admirable tumbleweed, native along the eastern base of the Rocky Mountains, had not crossed the plains to the Mississippi River until the emigrant trains began crossing in 1849. Squirrel tail (*Hordeum jubatum*), native throughout most of the Rocky Mountain region from Montana to Mexico and along our Atlantic coast, first became a weed east of the Mississippi River after its introduction with Western hay, although its brittle spikes with long barbed awns are well adapted for distribution by both wind and animals. The common dooryard plantain (*Plantago major*), although native in British America as well as in Europe and Asia, was evidently rare in the United States before the coming of Europeans. The Indians called it "white man's foot" because it seemed to spring up wherever the white man went. Our introduced weeds have rarely spread in advance of the sheep herder or the lumberman. We are forced to the conclusion that the plants which have become weeds of the farm have spread more through the agency of man than through all the natural agencies combined. Man tills the soil, subdues the native vegetation, and creates the conditions under which plants become weeds. He also introduces and distributes the seeds, unintentionally in most cases, but nevertheless effectively.

WEED MIGRATION BY ARTIFICIAL MEANS.

An analysis of the various artificial means of weed migration can not fail to impress one with their comparative importance, and it may lead to a recognition of ways in which artificial distribution can be checked.

ROOTS AND SEEDS CARRIED BY FARM MACHINERY.

Roots, rootstocks, and bulbs are sometimes carried from field to field and from farm to farm by plows, harrows, and cultivators. Some plants which are propagated chiefly by underground parts are distributed almost exclusively by these tools. The aerial bulblets or sets

of the wild garlic (*Allium vineale*) (fig. 67, *a*) often fall and take root close to the parent plant. The secondary or underground bulbs, if undisturbed, remain crowded together, sending up the little tufts of bluish-green shoots. These bulbs spread very slowly until they are scattered by the plow or harrow. The tubers of live-forever (*Sedum telephium*) (fig. 67, *b*) persist year after year in the same place, sending up a slowly increasing clump of succulent stems, but rarely spreading until they are scattered about by the plow and cultivator. In some places where the trumpet creeper (*Tecoma radicans*) has become a very persistent and aggressive weed it does not produce seeds, but is propagated exclusively by its long, tough roots, which are distributed by cultivating tools. The rootstocks of couch grass, bouncing bet, and St. John's wort, and the roots of bindweed, milkweed, and sometimes those of Canada thistle are scattered by cultivating tools. These roots and rootstocks are not often carried beyond the limits of the farm, however. Seeds are frequently carried farther in farm machinery, especially in self-binders and thrashing machines, which go from farm to farm without being cleaned.

FIG. 67.– Roots and bulbs scattered by cultivating tools: *a*, wild garlic; *b*, live-forever.

SEEDS AND BULBS CARRIED IN NURSERY STOCK.

Seeds, bulbs, and rootstocks of weeds are too often carried in nursery stock or among garden plants. Nut grass (*Cyperus rotundus*) was introduced into Arkansas with strawberry plants from New Orleans and into southern California with orange trees from Florida. It is said to have been first introduced into this country with garden plants brought from the West Indies. Wild onion (*Allium vineale*) has been introduced into many lawns, from Philadelphia to Atlanta, in sods used in making the lawns. It was introduced into northeastern Ohio among bulbs of grape hyacinth brought from the Atlantic Coast.

WEED SEEDS CARRIED IN PACKING.

Weed seeds are often transported in the packing of crockery, glassware, and castings. The cheaper grades of imported crockery are usually packed in cheap hay or straw, in which the presence of seeds

may be taken as a matter of course. Upon reaching America this crockery usually passes through the hands of the wholesaler and jobber to the retailer without repacking, thus gaining a wide distribution. When it is finally unpacked, the hay or straw is often thrown out on a vacant lot or, still worse, is used for stable bedding and then hauled out to the fields with the manure. The woolly mullein (*Verbascum phlomoides*), native in France, is supposed to have been introduced at Dickeys Mills, Ky., in crockery packing. Two species of long-awned chess (*Bromus tectorum* and *B. sterilis*), both European grasses, were first found at Denver, Colo., in the vicinity of a crockery store.

Seeds are sometimes carried long distances in wool. An evidence is found in the strange plants, chiefly bur bearing, that spring up about woolen mills and in fields where wool waste from these mills has been used as a fertilizer.

WEED SEEDS CARRIED IN HAY.

The transportation of hay offers a most ready and dangerous means for the dissemination of weed seeds. It is dangerous because it is one of the most difficult artificial means to control. Hay can not be readily inspected to detect the presence of weed seeds, and even if they are known to be present their removal is impracticable. An old tradition states that the Canada thistle was first introduced into eastern New York in hay brought from Canada to feed the horses of General Burgoyne's army. One of the most southern localities in which the Canada thistle has persisted as a weed is Remington, Va., formerly Rappahannock Station, which was the supply station for General Grant's army before the campaign of the Wilderness. The Canada thistle and other weeds of similar character may be found around many of the abandoned lumber camps in Maine, Michigan, and Wisconsin. The Russian thistle has been quite extensively introduced during the past six years in hay used at railway construction camps in North Dakota, Nebraska, and Montana. A single small consignment of Western prairie hay, cut in Kansas or Oklahoma, as indicated by the plants contained, was examined in Michigan with the result of finding fifteen species of weeds. These included mature seed-bearing plants of buffalo bur (*Solanum rostratum*), bull nettle (*Solanum elæagnifolium*), and tumbleweed (*Amaranthus albus*).

WEED SEEDS CARRIED IN COMMERCIAL SEEDS.

Impure commercial seeds afford the most important means for the transportation of weed seeds. It may be safely asserted that more of our foreign weeds have come to us through impure field and garden seeds than by all other means combined, and it is equally certain that weeds have been scattered about through this country in the same manner. English grasses were grown at Springfield, Mass., as early as 1658, and some introduced European weeds were recorded soon

afterwards. In 1672 Mr. John Josselyn published in New England's Rarities a list "of such plants as have sprung up since the English planted and kept cattle in New England." This list, comprising twenty-two species, includes couch grass, shepherd's purse, dandelion, groundsel, sow thistle, pigweed, dog fennel, and burdock. It is more than probable that the seeds of most of these plants were introduced with European seeds, which could not have been well cleaned with the rude appliances then in use. Where modern methods of cleaning are used, weed seeds to secure extensive transportation with commercial seeds must be of, approximately, the same size and weight as some common commercial seed that is harvested and thrashed in bulk, such as small grain, grass, clover, and flax. Plants that are handled separately, like corn, cotton, and many of the vegetables, present little opportunity for the admixture of weed seeds. The weed and the crop with which its seeds are distributed must have, approximately, the same period of growth and must reach maturity at the same time.

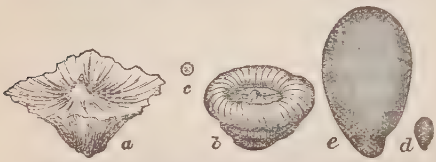

FIG. 68.—Russian thistle: *a*, fruit, seed surrounded by dried calyx, enlarged; *b*, seed removed from calyx, enlarged; *c*, same, seen from above, natural size; *d*, flax-seed; *e*, same, enlarged.

The seed of Russian thistle (*Salsola kali tragus*) (fig. 68, *a*, *b*, *c*) was brought to South Dakota and sown with flaxseed (*Linum usitatissimum*) (fig. 68, *d*, *e*). Since its first introduction we have records of its transportation in flaxseed, oats, wheat, and alfalfa.

Wheat (*Triticum vulgare*) (fig. 69, *a*, *b*), which is one of our most important commercial grains, is permitted to act as a transporting agency for many weed seeds. The seeds carried with wheat vary in different parts of the country. In Maryland, Virginia, and Tennessee, the southeastern part of the wheat range, the bulblets of wild onion are often present and are most injurious, as they ruin the flour. They are not seeds, but they perform the office of seeds in the reproduction of the plant, and should the wild onion be introduced in a region where wheat growing is conducted on a large scale, it would probably spread much more rapidly than it now does. Chess (*Bromus secalinus*) (fig. 69, *c*) is found in wheat in nearly all wheat-growing regions. With modern cleaning machinery it may be removed almost completely, so that there is little excuse for sowing chess with wheat. Cockle (*Agrostemma githago*) (fig. 69, *d*, *e*) is found in wheat, especially throughout the North. Cockle seeds are normally somewhat smaller

FIG. 69.—Wheat and its most common impurities: *a*, wheat grain, enlarged; *b*, *b*, same, natural size; *d*, seed of cockle, enlarged; *e*, same, natural size, smaller than cockle seeds developed by cultivation; *c*, spikelet of chess, inclosing seed, natural size.

than wheat grains. In some parts of the Northwest, where wheat for sowing has been cleaned year after year by steam cleaners, all the cockle seeds except the largest ones have been removed, and these have been sown until a large-seeded strain of cocklebur has been bred, which is very difficult to separate from wheat.

Oats (*Avena sativa*) (fig. 70, *a*, *b*) are lighter and more difficult to clean than wheat, and therefore, in spite of the fact that they are cultivated and shipped to a much less extent than wheat, they are responsible for nearly as large a distribution of weed seeds. The seeds that are found as impurities in oats are usually, as might be expected, different in shape from those most common in wheat, although the elongated grain of chess is common to both oats and wheat. On the Pacific Coast four varieties of wild oats are common among the cultivated species. These are the common wild oat (*Avena fatua*) (fig. 70, *c*), bastard oat (*Avena fatua glabrescens*) (fig. 70, *d*), slender oat (*Avena barbata*), and fly oat (*Avena sterilis*). One of these, the wild oat, has been found as far east as Illinois, but has not become abundant enough to be troublesome east of the Mississippi River. Wild mustard (*Brassica sinapistrum*) (fig. 70, *e*, *f*, *g*, *h*) is common and increasing in oats and spring wheat from New England to Oregon. The small shot-like seeds of the mustard (fig. 70, *g*) could be readily separated from the oat were it not that the mustard pod is often broken by the thrashing machine into segments which retain the seed and which are of about the same size and weight as the oat grain.

FIG. 70.—The oat and some of its common impurities: *a*, cultivated oat; *b*, same, enlarged; *c*, wild oat, natural size; *d*, bastard oat, natural size; *e*, pod of wild mustard; *f h*, sections of same, enlarged; *g*, wild mustard seed, enlarged.

Weed seeds have doubtless been transported with the seeds of red clover (*Trifolium pratense*) (fig. 71, *a*, *b*) more largely than with any other kind of commercial seeds. More weed seeds are mature in autumn, when clover seed is harvested, than earlier in the season, when other crops are cut, and the seeds of a great many weeds being, approximately, of the same size as those of clover, their separation is more difficult from clover than from wheat, oats, or barley. Even after passing through the modern seed-cleaning machines red-clover seed is often not more than 95 to 97 per cent pure, while less than one-half of 1 per cent of impurity is left in wheat after it has passed the cleaners now in use in flouring mills. A standard of purity of even 95 per cent has rarely been approached in red clover until within the last ten

years, and even now there is a sufficient demand for cheap seed to keep an uncleaned article on the market. This uncleaned seed rarely passes through the hands of large dealers and is seldom exported. The weed seeds most common in clover seed are the following: Rib grass (*Plantago lanceolata*) (fig. 71, *m*, *n*), pigeon grass (*Setaria glauca*) (fig. 71, *i*, *j*), sorrel (*Rumex acetosella*) (fig. 71, *o*, *p*, *r*, *s*), black bindweed (*Polygonum convolvulus*) (fig. 71, *c*, *d*, *e*), blackheart (*Polygonum lapathifolium*) (fig. 71, *f*, *g*, *h*), and bracted plantain (*Plantago aristata*) (fig. 71, *k*, *l*). Seeds of white cockle, ragweed, prickly lettuce, peppergrass, Canada thistle, bull thistle, oxeye daisy, and wild carrot are not infrequent, while those of dandelion, pigweed, careless weed, chicory, and many other species are occasionally found. The presence or absence of some species depends on the locality where the seeds are

FIG. 71.—Clover seed and some of its impurities: *a*, clover seed; *b*, same, enlarged; *c*, fruiting calyx of black bindweed, inclosing seed, enlarged; *d*, seed; *e*, same, enlarged; *f*, fruiting calyx of blackheart, inclosing seed, enlarged; *g*, seed; *h*, same, enlarged; *i*, seed of pigeon grass; *j*, same, enlarged; *k*, seed of bracted plantain; *l*, same, enlarged; *m*, seed of rib grass; *n*, same, enlarged; *o*, fruiting calyx of sorrel; *p*, same, enlarged; *r*, seed; *s*, same, enlarged.

grown, as none of the above-mentioned species except ragweed, pigeon grass, and sorrel are universally abundant throughout the red-clover region. Rib grass is recommended as a forage plant in Europe, and it is said to have been sown for this purpose in New England at an early date. It owes its introduction and wide dissemination, however, much more to impure clover seed than to its use as a forage plant. In 1888 a local dealer in a small town in Michigan offered for sale as clover seed a mixture that contained nearly 40 per cent of rib-grass seed. Evidently no attempt had been made to clean this seed, but where rib grass is abundant in the clover fields, even with the greatest care, its seed is almost certain to appear as an impurity in the clover seed. It is almost impossible to separate it completely, even with modern

cleaning machinery, but nearly all other weed seeds can be cleaned from red-clover seed.

Seeds of white clover and alsike clover are more difficult to clean than those of red clover, especially if they contain seeds of sorrel or peppergrass. A large proportion of the white-clover seed used in this country is imported, and as it usually enters into mixtures for lawns and permanent pastures it is doubtless responsible to a large extent for the present wide distribution of sorrel. The smaller weed seeds, like those of moth mullein and the fleabane daisies, are doubtless distributed to a considerable extent in grass seeds, but a large proportion of the impurities in grass seeds usually consists of the seeds of other grasses.

WEEDS INTRODUCED AS USEFUL OR ORNAMENTAL PLANTS.

A few of our most troublesome weeds have been intentionally introduced for use or ornament. Rib grass, as already mentioned, is said to have been sown for forage in New England in the early colonial days. The seed of oxeye daisy is said to have been brought to Rhode Island about 1815 and planted to obtain horse feed. It is recorded, however, as having been abundant and injurious in grass lands in Massachusetts as early as 1783. It has often been planted in gardens for ornament, and has doubtless escaped thence to the fields. The wild garlic (*Allium vineale*), which is now the most injurious weed from New Jersey to North Carolina and Tennessee, is said to have been introduced into the gardens of the early settlers at Germantown, Pa., for use as a flavoring plant, like our common onion. Chicory is said to have been introduced for greens by Governor Bowdoin, who brought plants from Holland in 1785 and planted them in the grounds about his residence at Mount Bowdoin, Dorchester, Mass. Chicory now overruns all the waste ground in that vicinity.

Purslane was cultivated for greens in the gardens of Massachusetts as early as 1672. Early in the present century it was taken from New York to Michigan to be used as a pot herb, and there are doubtless many instances unrecorded where this pest of the garden has been purposely planted for use. Live-forever, which has become so troublesome in central New York and in some New England States, was introduced for ornament, as a medicinal plant, or as a curiosity in nearly every locality where it has since spread. Bladder ketmia, bouncing bet, caraway, cornflower, and the annual morning-glories have in nearly all cases where they are now abundant escaped from old flower gardens. Golden hawkweed, wild carrot, ramsted, and squirrel tail have also been planted in flower gardens. Squirrel tail and ramsted have been advertised as ornamental plants in American seed catalogues within the last five years.

The water hyacinth, which is stopping the drainage in some of the

smaller streams in Florida and Louisiana and even threatening navigation in the St. Johns River, is a notable example of an escaped ornamental plant.

SPECIAL AVENUES OF WEED MIGRATION.

Certain means of introduction and routes of transportation are indicated by the names "ballast plants," "roadside weeds," and "weeds along the towpath." There is need of still one more term of this class, "railway weeds." When sailing vessels and earth ballast were used much more than at present, the ballast grounds at Philadelphia, New York City, Boston, and Baltimore were favorite collecting grounds for botanists, as they continually presented species new to the country. One hundred and three species were taken in ballast

FIG. 72.—Map showing distribution of wild carrot, prickly lettuce, and chondrilla.

from Buenos Ayres to New Zealand within a period of a few years. Roadsides in the country are usually lined with weeds, the seeds of which have fallen from loads of hay and grain and from the fur of animals. In some parts of northeastern Oregon the sheep trails are lined with red chess (*Bromus rubens*), the long barbed awns of which cling to wool. Many plants new to New York have been introduced along the Erie Canal. A large proportion of the seeds doubtless came in the hay and grain fed to the horses and mules along the towpath. The introduction of weeds from this source increased to such an extent that in 1847 the legislature of New York passed a special law requiring the destruction of "thistles and other noxious weeds growing on the banks and sides of canals." The railroad has superseded the canal in the transportation of weed seeds as well as in that of

passengers and freight. Before the Canadian Pacific Railway was completed, the tumbling mustard, previously unknown in the Northwest Provinces, was found at many points along the line. Many other weeds have migrated westward along this railway, some of them almost keeping pace with the work of construction. Railway transportation offers many facilities for the migration of weed seeds. In the West, tumbleweeds are frequently blown into the trucks of cars and are carried long distances. There are records of two instances, one in North Dakota and one in Minnesota, in which grain cars were wrecked, each case resulting in an abundant introduction of the Russian thistle. This plant seems to be particularly a railway weed. It has appeared first along the railways in sixteen of the twenty-one States and Territories in which it has been introduced. In nearly all

FIG. 73.—Map showing distribution of Canada thistle, Russian thistle, and nut grass.

the States where it is now found its wide distribution has been effected chiefly by the railways, in spite of the fact that the railway companies have generally done more than all other parties to combat it.

HISTORY OF WEED MIGRATIONS.

PRESENT DISTRIBUTION OF SOME PROMINENT WEEDS.

The accompanying maps (figs. 72 and 73), showing the present geographic distribution of some typical weeds in the United States, will indicate some of the peculiarities in the ranges of weeds. Some plants are restricted to the northern part of the country and others to the southern part. These restrictions are evidently due chiefly to differences in temperature, length of growing season, and moisture. The mustards are generally confined to the North, while the nightshade

and spurge families are more abundantly represented in the South. Canada thistle, Russian thistle, wild carrot, and prickly lettuce are mostly restricted to the North. All of them extend into Canada, but for lack of sufficient data their ranges are not indicated on the map beyond the borders of the United States. Canada thistle introduced on the Gulf Coast does not survive. The other species, while surviving in the South, do not increase as rapidly or crowd out other vegetation to as great an extent as they do in the North. Nut grass (*Cyperus rotundus*) is very troublesome in many localities from North Carolina to Arkansas and Texas, but it does not thrive farther north, where the frost reaches deep enough to affect its tubers.

Some weeds appear to thrive best on soil that has been worn out by long cultivation. Examples are found in the oxeye daisy and wild carrot, both of which were introduced on our Atlantic Coast more than a century ago. They are both slowly migrating westward, generally keeping twenty-five years or more behind the advance of cultivation, that is, they rarely become abundant in a locality that has been settled less than twenty-five years. The oxeye daisy was introduced along the shores of the Great Lakes by the early French missionaries, and, although it has persisted in some of their camping places, it has not spread in those localities until within recent years. Quite the opposite tendency is exhibited by fire weed (*Erechtites hieracifolia*) and bull thistle, which thrive best on recently cleared land and usually decrease or disappear entirely after the land has been cultivated a few years.

Two plants whose natural adaptations for spreading are almost identical may differ entirely in their actual migrations on account of their different relations to human agency. Prickly lettuce and chondrilla were introduced into this country at about the same time. Each produces seeds from early in July until frost kills the plant in autumn. The seeds (akenes) of both species are of nearly the same size, approximately the same in number on average plants, and provided with the same kind of stalked pappus for distribution by the wind. Chondrilla was introduced in West Virginia, where comparatively little clover seed or hay is produced for shipment, and it has scarcely spread beyond the valley of the Potomac River. Prickly lettuce, introduced in Ohio and Michigan, soon reached localities where the chief industries were the production of hay and clover seed for shipment, and its distribution has been exceedingly rapid.

The germinative vitality of the seed has also a potent influence on the plant's migrations. Canada thistle is said to have been introduced in Lower Canada more than two centuries ago, but its present distribution scarcely exceeds that of the Russian thistle, introduced less than a quarter of a century ago. The chances of the distribution of seeds are nearly equal for the two species, but the production of perfect seeds in the Canada thistle is very irregular, while the Russian

thistle seldom fails to produce a good supply of seeds capable of germination.

THE DIRECTION OF WEED MIGRATION.

A study of the origin of weeds now in this country will impress one with the largeness of the number that have been introduced from Europe in comparison with the number of native species or of species received from other directions. In the list of 200 weeds of the United States published in the Yearbook for 1895, 108 species are of foreign origin, while 92 are native. Of the 108 introduced species, 64 are native in Europe and 30 are ascribed to the Old World in general, only 2 Asiatic species in the list having established themselves as weeds in this country without being first distributed in Europe. Africa and Australia are not represented among our weeds, while Central and South America have contributed only 12 or 15 important species, most of which are confined to the Gulf States. A list of the plants of Michigan published in 1892[1] contains 1,604 indigenous species, of which 22 are recognized as injurious weeds, and 142 species introduced from Europe, of which 57 have become troublesome weeds.

A list of Kansas weeds[2] enumerating 209 species contains 129 native species, 42 introduced from Europe, and 38 from all other sources. Eighteen species native in the States east of the Mississippi River have been introduced into Kansas in opposition to the prevailing winds and the direction of the drainage, while only 3 species are mentioned which have come from the Rocky Mountain region with both of these natural forces in their favor.

In an article on the weeds of California[3] 110 species are mentioned as troublesome in that State. Of these, 53 are native, 43 are introduced from Europe, 5 are from the eastern United States, 3 from Central and South America, and only 2 from Asia. Even in the States bordering the Gulf of Mexico the number of weeds introduced from Europe in cultivated land equals or exceeds those from Mexico and South America. Canada thistle, bur clover, and skunkweed have been taken from California to Australia, where they quickly became naturalized and are now rapidly spreading.

The general trend of weed migration is westward, from Europe to America, from the Atlantic States to the Mississippi Valley and onward to the Pacific Slope, and even across the Pacific Ocean to Australia and New Zealand. Less than half a dozen American species have become troublesome in Europe. Only three or four species from west of the Mississippi River have become widely distributed in the Eastern

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[1] Michigan Flora, by W. J. Beal and C. F. Wheeler, Thirtieth Annual Report of the Michigan State Board of Agriculture.

[2] Bulletin No. 57, Kansas State Agricultural College, Weeds of Kansas, by A. S. Hitchcock and J. B. S. Norton.

[3] Weeds of California, by E. W. Hilgard, Report of the Agricultural Experiment Station of the University of California for 1890.

States, and only one or two weedy species have entered the country on the western coast from Asia or the islands of the Pacific Ocean.

PREDOMINANCE OF EUROPEAN WEEDS.

One of the chief reasons for the preponderance of European species among our introduced weeds lies, doubtless, in the fact that our commerce with Europe is greater than with all the other continents combined. Until within the last twenty-five years our traffic with Asia, Australia, and South America has been comparatively unimportant, and even now we have very little direct communication with Africa. This country was settled by Europeans who have planted European crops with seeds imported from Europe. It is but a natural consequence of these conditions, therefore, that among the introduced weeds of this country those of Europe should predominate.

WESTWARD TRANSPORTATION OF IMPURE COMMERCIAL SEED.

It is only within the last half century that the exportation of American-grown field seeds, such as clover, grass, and grain seeds, has equaled the importation of seeds of these kinds from Europe. During the earlier years, when the greater proportion of seeds sown in this country came from Europe, the imperfections in the gradually improving seed-cleaning machinery made it impossible to clean seeds as perfectly as those now exported to Europe may be cleaned. Even now, owing to the greater number of weeds in Europe with seeds adapted for distribution in field seeds, and the fact that the seed-cleaning machinery in common use there is generally inferior to the fanning mills used on the farms here, the commercial seeds as placed upon the market usually contain more impurities than do those sold by the seed growers in the United States, and unless extra care is exercised by European exporters in cleaning their seeds they are likely to contain more weed seeds than do those which are now shipped from this country to Europe. Thus the exchanges in commercial seeds with Europe have favored the westward migration of weed seeds.

Somewhat similar conditions have existed in the transportation of field seeds within the United States. The growth of clover, grass, and grain seeds for sowing, beginning on the Atlantic Coast, has been slowly moving westward, until now the chief supply is produced in the Mississippi Valley. As the standards of purity have been constantly improving during all these years, most of the seeds which are shipped toward the east contain less weed seeds than those which have been shipped westward. Two notable examples may be cited of weeds that have migrated eastward with commercial seeds. Yellow daisy (*Rudbeckia hirta*) is said to have been unknown in New England until clover and grass seeds were brought there from New York, and during the past few years bracted plantain

(*Plantago aristata*) has appeared in many places in the East, where its seed had evidently been sown with clover from the Mississippi Valley. These two instances are notable because of their singularity, but they also indicate that, were all other conditions equal, we might reasonably expect a greater eastward migration of weeds than we now have.

MIGRATORY WEEDS DEVELOPED BY CULTIVATION.

Another and very different reason why the course of weed migration coincides with that of cultivation lies in the physiological history of the plants themselves. The cultivation of the land beginning in the valleys of the Euphrates and the Nile has been extending westward for more than thirty centuries. Many of the weeds of agriculture as well as many of the cultivated plants had their origin in Asia Minor or in the region of the Mediterranean Sea. Cultivation produces the conditions of environment under which weeds develop. It also aids in producing conditions in the constitution of the plant itself which render migration possible. To become a weed a plant must be well adapted to exist and multiply under the conditions with which it is surrounded. The weeds of agriculture are usually surrounded with more or less artificial conditions, due to cultivation and grazing. To become a weed throughout a wide geographic range a plant must have a wide range of adaptability. The ranges of indigenous species are frequently limited by changes in the soil, temperature, humidity, intensity of sunlight, and length of growing season. Many indigenous plants are unable to withstand the changes brought about by cultivation. Thus, in Michigan, while 22 indigenous species have adapted themselves to the conditions of cultivation and have become weeds, 37 species which were formerly common are fast disappearing. Their places are being taken by 142 European species, which are rapidly becoming naturalized. All these introduced plants are found in cultivated ground or in waste land about villages in Europe. Instances are exceedingly rare of plants from uncultivated land in Europe becoming naturalized in America. Plants acquire a habit of growth suited to their environment. If they grow generation after generation under the same conditions, this habit becomes fixed and is not readily changed to suit different conditions. If, on the other hand, the environment of the plant is frequently changed, the plant either dies and becomes extinct or it acquires a flexible habit capable of adapting itself to a great variety of situations. The processes of agriculture, including the rotation of crops, grazing and trampling of animals, clearing of woodland, draining and irrigating, imply a continual change of conditions. The plants that survive these changes must necessarily acquire a considerable range of adaptability. This range is still further enlarged by transportation from one locality to another. The possibilities of transportation to considerable distances are many

thousand times greater by artificial means, such as affect plants of cultivated land, than by natural means, which must be depended upon by plants of wild land.

Nearly all the indigenous species of America that have become migratory weeds, as bur grass, cocklebur, squirrel tail, horseweed, and buffalo bur, are adapted to distribution by animals or wind, and have long had a wide range from north to south. They had, therefore, a considerable degree of adaptability before encountering the conditions of cultivation.

SUMMARY.

The discussion may be summed up in the following statement of facts and conclusions:

1. Weeds effect a dispersion of their kind independently of their external agencies by means of runners, rootstocks, running roots, and apparatus for throwing seeds.
2. The dispersion of weed seeds is aided by the natural agencies of wind, water, and animals.
3. Seeds are rarely carried long distances by natural agencies.
4. Weed migration is aided by man more than by all the natural means combined.
5. To become a migratory weed a plant must have a wide range of adaptability.
6. A plant acquires a wider range of adaptability under conditions of cultivation than in wild land.
7. The general direction of weed migration coincides with that of the progress of cultivation.

Weed migration may be checked by the following means:

1. By preventing the production of seeds and burs.
2. By using greater care in cleaning farm machinery moved from field to field.
3. By using greater care to prevent the transportation of seeds, bulbs, and roots with nursery stock.
4. By burning the "packing" of crockery, castings, etc.
5. By destroying weeds in the meadow or throwing them out as hay is baled.
6. By using greater care in cleaning commercial seeds.
7. By a consideration of the probable consequences before purposely introducing plants like chicory, purslane, or oxeye daisy.
8. By having "ballast weeds," "roadside weeds," and "railway weeds" watched for and destroyed before they become weeds of the farm.

COWPEAS.

(*Vigna catjang.*)

By JARED G. SMITH,
Assistant Agrostologist, U. S. Department of Agriculture.

ORIGIN AND GENERAL CONSIDERATIONS.

The cowpea is to the South what alfalfa is to the West and red clover to the North—a forage plant perfectly adapted to the needs of the region where it grows. The cultivation of this crop in America dates back to the early part of the eighteenth century. A South Carolina planter received a quantity of seed from a foreign source, which, according to certain authorities, was an English acclimatization society or the captain of a trading vessel from far-off India or China. From this small and obscure beginning cowpeas spread throughout the South, and their cultivation has been essayed as far north as Connecticut, New York, and South Dakota, and westward to California.

Cowpeas grow wild in far eastern tropical lands, including India, China, Siam, the Malay Archipelago, and portions of Central Africa, and have become an escape from cultivation in the southern United States and tropical America. From the South the plant has been carried in recent years to South Africa and Australia, so that it is now grown as a forage plant or for human food throughout all the warmer quarters of the globe. Cowpeas are in their relationship and habit of growth really beans, and not, as the name would indicate, peas. They belong to the genus Vigna, the members of which are largely represented in South Africa, and are closely related to the lablab, lima, and haricot beans of our gardens, as well as to numerous cultivated or half-wild garden sorts common in tropical Asia and America, but little known to us.

There are a very large number of named forms or varieties of this forage plant. New forms are constantly arising, due to variations in habit of growth, color of leaf, stem, and pod, and the shape and color of the seed. Variations from any chosen type are constantly appearing, and as one or another of these sports or forms gains sufficient local reputation a new name is applied and sooner or later the supposed new variety is placed upon the market. In this way one variety of cowpea may be cultivated in a dozen different localities under as many names, or a dozen different peas may bear the same name. The whole subject of the nomenclature of varieties is in a chaotic state and can be straightened out only after years of careful

study have been given to it by botanists and the experimental agriculturists. No valid conclusions can be drawn from the brief study of a subject so complex. Cowpeas pass through every gradation of form, from a short, stocky, upright bush having single stems a foot high with very short lateral branches to those with trailing runners growing as flat upon the ground as sweet-potato and melon vines, the prostrate stems 15 or 20 feet in length. The pods vary from 4 to 16 inches in length, and the peas are of every imaginable shade through white, yellow, green, pink, gray, brown, red, purple, and black, of solid colors or variously mottled and speckled, and of varying sizes and forms from large kidney-shaped to little round ones smaller than the garden pea. There is a like variation in the length of time the different forms require to ripen seed, some requiring eight or nine months, a few ripening in sixty days from the time of planting.

There seems to be a somewhat constant relation between the time required for attaining maturity and the habit of growth. The bush varieties ripen in a shorter season than the trailers, but a bush variety taken from the North will, in the course of a few seasons, assume the trailing habit and lengthen out its period of growth in any of the Southern States. Also, a runner or creeper requiring six to eight months for reaching maturity in Louisiana will, if planted each year a hundred miles farther north, gradually accommodate itself to the shorter season and at the same time shorten its runners, approaching more and more to the upright or "bush" habit of growth. There can be no hard and fast line of separation between bush peas, trailers, and runners. The best varietal character is probably the color of the seed. It is quite probable that more than one species is in cultivation. The "red" and "black" varieties are closely allied; the round "lady" peas form a separate group; the large "black-eyed" and "purple-eyed" are typical of another, and the variously mottled and speckled "whip-poor-wills" are only a degree removed from the solid-colored yellow, pink, and light-brown ones, and together would naturally be taken to constitute one species or variety. The black peas pass through various shades of red before maturity. The red varieties sometimes carry their change of color in ripening so far that they can not be distinguished from the black. The "black-eyed" and "purple-eyed" are of the same ground color, differing only in the color of the ring surrounding the eye. The various "crowders," yellow and white, the whip-poor-will, clay, and "yellow-eyed" forms have numerous crosses and so-called hybrids in which the fundamental yellows and browns form varying mixtures.

COWPEAS AND SOIL RENOVATION.

A field of cowpeas has been very happily designated "the poor man's bank," for in common with all its leguminous congeners, the field pea, clovers, alfalfa, and a score of others, this crop has the power of

increasing the fertility of the soil upon which it grows. This fact has long been accepted by farmers and students of agriculture, but until recent discoveries in Germany and America it was believed that the chief function of these plants was to pump up nitrogen from the subsoil reservoir to the surface by means of their long roots for the use and benefit of succeeding crops.

But experiments in the field and laboratory for the purpose of determining the causes of natural phenomena have taken the place of classroom philosophy and speculative reasoning. Within the last twenty years scientific workers have discovered that minute micro-organisms, or bacteria, which live within the tissues of the roots of leguminous plants take up free nitrogen from the gases in the soil, just as the higher plants and animals utilize the oxygen of the air. This nitrogen enters into combination to form nitric acid, which unites with the mineral elements of the soil to form nitrates, a kind of plant food exceedingly valuable to the growing crop. Nitrogen, when in combination with other elements, is an indispensable form of plant and animal food, but the free element can not be utilized, uncombined, by any of the higher organisms. Small amounts of nitrous acid are formed as a result of lightning discharges and are washed out of the air by the rains, to be in part absorbed by the soil, and in part carried by rivers and drainage waters into the sea. Free nitrogen exists only in the air and in the gases of the soil, but as ammonia, nitrous and nitric acid, nitrites and nitrates, it is present in varying quantities in the soil, the unbroken rocks, and the waters of continents and oceans.

The most available purchasable nitrogen is obtained either as saltpeter or nitrate of soda from the extensive deposits in the Peruvian deserts, or from some form of animal wastes, such as freshly ground bone, dried blood, guano, tankage, and fish scrap, and from cotton-seed meal and other like by-products of the oil mills. These fertilizers are all expensive, so much so that they can be profitably employed by the farmer only in intensive farming with specialized crops. The gain in yield with low-priced crops, such as corn, cotton, tobacco, cowpeas, and the grasses, using high-grade and costly fertilizers, is not commensurate with the additional expense. But every farmer, rich and poor, has over three thousand tons of atmospheric nitrogen resting on every acre of his farm, a certain quantity of which can be transformed into available plant food every time that he grows a crop of cowpeas, red clover, or alfalfa.

There are a great many acres of farming land in the South in need of renovation. The red uplands and yellow-clay soils were undoubtedly less fertile originally than the alluvial and black prairie soils, and the methods of cultivation which formerly prevailed have still further diminished their productiveness. In the days when every plantation

numbered its acres by the thousand and labor was cheap, the planter could afford to clear off the native forest growth and bring fresh fields into cultivation whenever the yields of cotton and tobacco fell below what was considered a profitable figure. The old field, stripped in a few years of its accumulated store of humus, was abandoned and allowed to grow up to weeds and underbrush. The forest again spread across it, and gradually, in the slow course of half a lifetime, the natural enrichment of its surface soil by the growth of the woodland grasses made it ready for another robbery.

But with the breaking up of the large estates and the abrupt change in the labor conditions this method of farming became no longer profitable or even possible. A planter with fewer acres could no longer afford to await nature's slow process of rejuvenating the soil. A new system of farming was necessary. The land must not be allowed to "go back." It must be kept up to the highest state of productiveness by a rotation of crops, a judicious use of commercial fertilizers, the growth of nitrogen-fixing leguminous crops, and good and thorough cultivation. To maintain the fertility of any soil the amount of humus or decaying organic matter in it must be kept up. Take two soils of as nearly as possible the same physical and geological formation, but the one rich in humus and the other lacking it, and fertilize them with equal quantities of commercial manures; the one which has the most organic matter in its composition will yield the largest crop. The soil on that field will stand drought better, will wash less under torrential rains, and be more friable and of better tilth. The average soils of the South need more humus. It can be best supplied by sowing more grass, more permanent pasture lands, more leguminous crops. In a word, plant cowpeas.

COWPEAS FOR FORAGE.

There is no forage plant better adapted to the needs and conditions of Southern agriculture than this rank, free-growing annual. It will thrive luxuriantly upon the rich, swampy, cane lands of Louisiana. On the driest and most sterile worn-out uplands it serves the admirable purpose of supplying a larger quantity and better quality of forage than any other bean or clover. And whenever a crop of cowpeas has been taken off a field the surface soil is left richer by a good many pounds of that most costly of all plant foods, nitrogen. The roots of the cowpea enter deeply into the soil, opening and loosening it far down for the benefit of the roots of the succeeding crops of corn, cotton, and tobacco. It has been found by experiment that the fertilizing value of the roots and stubble of the cowpea are very considerable, but not as great as that of the hay removed from the field. The best and most economical use of this forage crop is, then, to cut for hay, feed to stock, and return the stable manure to the soil. Plowing the whole crop under is less remunerative because there is much needless

waste of the muscle-making and fat-forming constituents of the plant which would bring more profit if turned into beef, pork, wool, cheese, or butter.

As regards the disposal of the crop, there is a wide variation in practice. The feeding value of vines and peas much exceeds their fertilizing value. But as between the practice of turning the vines under green in autumn and that of allowing them to lie on the ground during the winter, the latter is undoubtedly sometimes to be preferred, though theoretically wrong. Theoretically, to plow the vines under in autumn will be to save all the available nitrogen and convert the whole plant into humus. Practically, the turning under of so large an amount of watery green herbage is highly injurious, causing a too rapid decay and consequent "burning" or souring of the soil. The upper soil layers, freshly stirred and mellowed in autumn, lose more by leaching and washing than they do in an unplowed field covered by its winter mulch of decaying herbage, though in both cases there is a decided loss of fertility over what would result by following the peas with a crop of rye, winter wheat, the turf-forming winter oats, winter vetch, or crimson clover. The yields of forage are better on rich soils than on poor ones, but the beneficial effects upon the succeeding crop due to the growth of this one are not so marked in the former case as in the latter.

METHODS OF CULTIVATION AND HARVESTING.

Cowpeas are planted broadcast or in drills, very commonly between the corn rows after the crop is laid by. The amount of seed used varies from 4 quarts to 2 bushels per acre, the average amount being, perhaps, about 3 pecks. If sown in drills, 18 to 30 inches apart, less seed is required than when sown broadcast. The seed will stand being covered to the depth of 2 or 3 inches, but care must be taken to plant when the ground is neither too wet nor too cold, as the peas rot very rapidly under such circumstances. In regard to excess of moisture cowpeas behave like beans, and in the early stages delight in a warm, mellow seed bed. Much of the failure that has attended the attempted introduction of cowpeas into the Northern States is due to planting before the ground is warm enough. It must be remembered that this plant originated in the Tropics and that when transplanted to higher altitudes it makes its best growth in the hottest weather. It is even more susceptible to cold and wet than is Indian corn. Hence, proper delay in planting will permit economy in the use of seed. Where the vines are grown for hay, the yield will be larger if the seed is planted in drills and cultivated a time or two. The yield of peas is also larger when only a moderate amount of seed is sown and the vines have more space and light and air between them. It is also heavier from late-planted vines than from the very early ones. In tests to determine the relative value of different named varieties it has been found that,

as a rule, those which make the heaviest yields of vines also bear large crops of peas.

The vines should be mowed for hay when the peas are well formed and the leaves are first beginning to turn yellow. After wilting on the ground or in windrows from twenty-four to forty-eight hours, the hay is placed in small, thin piles, or cocks, and allowed to cure for several days, when it may be carted to the barn or stacked under sheds. The haymaking process is a difficult one, requiring more care and attention than in the case of red clover, because the broad leaves and thick stems contain a larger amount of water. The hay must be placed in cocks before the leaves become brittle, and the piles must be small enough to allow free circulation of air to the center of each. Bright cowpea hay, clean and well cured, is worth as much as the best red-clover hay, and there is no good reason why the Southern farmers and planters should buy the Northern-grown article for their working stock or for fattening their cattle. Every ton of hay used on the estate should be grown there. Another method of curing hay is to stack the vines in a pen or rack of rails or poles so arranged as to allow the air to enter every part of the pile. This stacking over poles is the best where the vines are pulled, or where the trailing and creeping sorts are used. The bush varieties are the best for hay, because of the greater ease with which they may be mowed and handled. They also hold their leaves better than the ranker trailing sorts. The yield of hay varies according to the fertility of the soil upon which it is raised, whether it is grown on rich lowlands or on the drier and more sterile uplands. In the Gulf States cowpeas will probably give an average yield of 2 to 3 tons per acre, while 4 to 6 tons are not uncommon. Farther north the average will range from 1½ tons in Ohio to 2½ tons in Arkansas, Missouri, and Tennessee. As with other crops, the time of planting, the character of the soil and of the cultivation, and the amount of rainfall have much to do with the yield. Along the Gulf it is one of the best hay crops. North of the latitude of the Ohio River it is chiefly valuable as an addition to the list of drought-resistant, summer-soiling crops and as a crop that will yield a considerable amount of forage on soil too sterile to grow red clover. The commercial value runs from $6 to $20 per ton, being governed by the relative abundance of other grades of hay and fodder. Its feeding value is equal to that of the best red clover, and the hay ranks high in palatability and digestibility.

COWPEAS FOR SWINE AND CATTLE.

When cowpeas are planted for green manure, it is an excellent practice to turn hogs into the field about the time that the first peas are ripening. Young pigs thrive amazingly on the succulent foliage and well-filled pods, and the quality of the pork raised on such a healthful

and nutritious diet is very fine. This is a very profitable method of fattening hogs or of preparing them for topping off with corn or sorghum for market. An acre of ripening cowpeas will pasture from fifteen to twenty hogs for several weeks, and the gain in fertility from the droppings of the animals during that period will more than counterbalance the fertilizing value of the forage eaten. The rapid increase in weight will thus represent so much clear profit, and the farmer is richer by half a ton or more of prime pork for every acre planted. Chickens and turkeys also eat the ripe peas and do well upon them. Cattle and horses are sometimes pastured on them, but the safer and more economical way of feeding cowpea vines to such stock is to cut or pull and feed partially wilted. There will be less waste and destruction from trampling, and if each animal is given only so much as it can eat clean, the greatest economy as well as greatest profit will result. Furthermore, cattle and sheep are liable to bloat if allowed to eat too ravenously of cowpea vines or any other rich and succulent forage, and by using it as a soiling crop the danger may be more readily controlled and the loss prevented. The report has been sent out from some of the Northern experiment stations, where this forage plant is not ordinarily cultivated, that cattle will not eat the green vines except after having been starved to it, and then only sparingly. We have seen Western horses and ponies that would not touch red clover or a grain ration of oats, and have heard of Eastern stock that would not eat alfalfa hay. But these few adverse cases do not prove that red clover, alfalfa, and oats are not good forage. With the cowpea the case is similar. It is very rarely that any Southern planter reports that this forage is refused by any kind of stock.

COWPEAS FOR ENSILAGE.

Reports are very conflicting in regard to the value of this crop for ensilage. There is much positive testimony both for and against, some authorities stating that the quality is excellent and others that the vines contain too much water, the product of the fermentation being a slimy, foul-smelling mass, unfit for food for any kind of animals. From reports on the subject it is to be believed that the attempt to convert cowpea vines into good ensilage can not be made with such uniform success as in the case of red clover. The percentage of water in the tissues is too high, and the mechanical difficulties in the way of running a mass of tangled herbage through the feed cutter are too great. Special machinery would have to be constructed for the purpose. Indian corn will probably remain for many years the best all-round forage plant for this purpose. The consensus of opinion among agricultural workers seems to be that ensilage made from any legume, whether it be cowpeas, vetches, soja beans, alfalfa, or the clovers, does not equal in feeding value good hay made from the same. Under

certain conditions that arise in the silo the crude protein is converted into indigestible or insoluble nitrogenous compounds. The cowpea or clover ensilage is then valuable only for the carbohydrates that it contains, and either corn or sorghum is far superior to it.

HARVESTING THE SEED.

The majority of farmers harvest only enough seed of cowpeas to plant again the next season. The ripe pods are picked by hand and are stored in barrels until needed or are thrashed out by machine or with flails on the barn floor during the winter. Sometimes, if the crop is heavy enough to render it profitable, the vines are run through an ordinary thrashing machine from which the concaves and alternate teeth of the cylinder have been removed. But a machine breaks and bruises more of the seed than when the pods are first picked off by hand. Fully 95 per cent of the seed placed upon the market is hand picked. The yield per acre varies according to the varieties and the method of cultivation. Eight to twelve bushels is a fair average of the amount that can be obtained when the peas are planted in the corn rows. Sown alone, broadcast or in drills, yields of from twenty to thirty-five and even, in rare cases, fifty bushels are obtained. The Black, Unknown, Red Ripper, Clay, and Calico varieties are all heavy seed bearers. Lady and White Crowder are good for table use and also yield well. The Black-eyed, Red Crowder, and Whip-poor-will or Speckled are very widely cultivated and find ready sale. Those which make the largest growth of vines for green manure, as a winter soil mulch, for hay or soiling are the Unknown, Red Ripper, Southdown, and Clay. Whip-poor-will, Black-eyed, White, and Red Crowder ripen in from twelve to fourteen weeks, and hence are adapted to cultivation farther north than the very late, but ranker growing, Unknown, Wonderful, Red Ripper, Black, and Gourd varieties. The New Era and Lee ripen seed in from six to seven weeks, and hence are the ones to recommend for summer-soiling crops in the upper prairie region of the Mississippi Valley or anywhere else that an early maturing cowpea is required. This is one of the species of cultivated plants which is very readily modified by change of habitat. Early and late maturing forms may be found of every strain that has been in cultivation for any considerable time.

THE FEEDING VALUE OF COWPEAS.

The feeding value of cowpea vines is very high, as shown by both feeding tests and chemical analyses. As hay the vines are more valuable than fed green for soiling purposes. A comparison with red clover and alfalfa is made in the table on the next page, a compilation[1] of the averages of a number of analyses from various sources.

[1] Handbook of Experiment Station Work, Appendix, 1893.

Feeding value of cowpeas compared with red clover and alfalfa.

Article.	Fresh or air-dry material.						
	Number of analyses.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
Cowpeas:							
Green	10	83.6	1.7	2.4	4.8	7.1	0.04
Hay	8	10.7	7.5	16.6	20.1	42.2	2.9
Red clover:							
Green	43	70.8	2.1	4.4	8.1	13.5	1.1
Hay	38	15.3	6.2	12.3	24.5	38.6	3.9
Alfalfa:							
Green	23	71.8	2.7	4.8	7.4	12.3	1.0
Hay	21	8.4	7.4	14.3	25.0	42.7	2.2

Article.	Calculated to water-free substance.				
	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
Cowpeas:					
Green	10.5	14.3	29.0	43.6	2.6
Hay	8.5	18.6	22.5	47.2	3.2
Red clover:					
Green	7.2	15.3	27.8	45.8	3.9
Hay	7.3	13.5	31.3	43.0	4.9
Alfalfa:					
Green	9.4	17.1	26.2	43.9	3.4
Hay	8.1	15.6	27.3	46.6	2.4

A study of the percentages here given will show that the green vines contain more water, less protein or nitrogenous, muscle-making food, and less of the fat-forming crude fibers, fats, and nitrogen-free extracts than either the green alfalfa or red clover. The air-dry hay, however, contains more protein than either of the others, less fiber, more nitrogen-free extracts than the red clover, and more fat than the alfalfa. As is the case with leguminous forage plants in general, a ration of cowpeas, to be well balanced, requires the addition of some coarse fodder, such as corn stover, sorghum, timothy, Bermuda, or prairie hay, otherwise a portion of the protein will be wasted.

FERTILIZERS.

It has been found that, as a rule, it does not pay to use high-grade commercial fertilizers on cowpeas; this, however, depends a good deal on the soil and on what crop is to follow this green manurial one. It is usually unprofitable to fertilize with expensive nitrogen, in the form either of nitrate of soda or of guano, and even the organic nitrogen of cotton-seed meal does not act upon this crop as rapidly as upon cotton and the cereals. The nitrogen of the fertilizers seems not to influence the percentage of protein in the crop, and the general opinion of agriculturists in the South is that it does not cause a

sufficient increase in yield of vines to pay the cost. At the Delaware Station 160 pounds of muriate of potash per acre doubled the yield of vines, and superphosphate produced no effect. At the Georgia Station combinations of superphosphate and potash gave the best results, but later experiments there indicated that large amounts of potash are unprofitable, and that superphosphate at the rate of from 200 to 400 pounds per acre gave better results. Superphosphates are very much preferable to untreated rock phosphate. The latter can be sold at much lower rates, and it remains to be seen whether it would not be a profitable method to apply the soft phosphate to the cowpeas for the benefit of the succeeding crop in the rotation, for it has been found that the insoluble phosphoric acid of the untreated rock becomes changed to forms available as plant food in the presence of large amounts of decaying vegetable matter in the soil. If it is found that this process can be relied upon, then the cowpea will have another valuable quality added to it, namely, that of being able to change into high-grade and more costly superphosphate the low-grade and cheap but unavailable phosphoric acid of the untreated rock.

The chief functions of this crop, then, are to furnish large amounts of nitrogen abstracted from the air and fixed in the roots and stubble in a conveniently available form for the use of succeeding crops; second, to produce a large yield of vines and peas rich in digestible protein, which, either as hay or for soiling purposes, will take the place of concentrated nitrogenous foods; and, third, to supply humus, which acts directly and indirectly to produce fertility by breaking down and rendering available the basic minerals of the soil. The fertilizing value of the nitrogen in the vines is entirely dissipated or greatly diminished by weathering when they are left on the surface of the field during the winter. Hence, to secure the full value, the cowpeas should be fed and the stable manure returned to the field. If the vines are plowed under in autumn, a winter forage crop, such as winter oats, crimson clover, rye, or vetches, should be planted to prevent the leaching and washing action of the winter rains.

THE IMPROVEMENT OF OUR NATIVE FRUITS.

By L. H. Bailey,

Professor of Horticulture at Cornell University and Horticulturist of the New York (Cornell) Experiment Station.

INTRODUCTION.

It is a popular subject, this evolution and amelioration of our native fruits. Everyone is convinced that there is promise in these fruits, and writers are always demanding that some person other than themselves shall take up the improvement of them. Now, the chief reason for supposing that these fruits should be domesticated seems to be the most obvious fact that they have merit in themselves; and yet, paradoxical as it may be, this is not sufficient reason to recommend their amelioration. It is not the thing which is intrinsically the best that necessarily deserves the most attention, but the thing which is most needed. We shall find our most helpful suggestions from a reflection upon what has been accomplished and how it has been done, rather than from a mere objective study of the kinds of our wild fruits. It is proposed, therefore, to divide this article into two parts: (1) What has been done, and (2) what probably should be done.

WHAT HAS BEEN DONE.

The most obvious truth that strikes one when he attempts to make a reflective or historical study of the improvement of our native fruits is the fact that in nearly every case the amelioration has come from the force of circumstances and not from the choice or design of men. The colonists, in common with other good people, knew and loved wine. The beverage has been a hand to hand (or more truthfully a hand to mouth) companion of the human family from the first. The attempt was therefore early and heroically made to grow the European or wine grape in eastern America; but the attempt failed. In sheer distress of failure, the grape grower was driven to the use of the native grape. How literally true this was the reader may learn by reading the history of the grape colony of the Dufours in Kentucky, and then in Indiana late in the last century and early in this, and noticing the fact that the existence of the colony as such depended upon the success of the wine. The salvation of the colony was the Alexander, or Cape, grape, which, in a most surreptitious way, had transferred itself from the wild into the plantations which were at first designed to grow the European varieties; and later on, John Adlum's famous Catawba,

a product of the Carolina highlands, added the crowning glory and success to the experiment, and thence spread itself along the Ohio and over the Union. At the very time that the Alexander and the Catawba were driving out the Old World types, the grape growers were making a most determined opposition to the native grapes. The fact is that the native grapes, the types which we now cultivate, came into domestication in spite of us.

The native plums, of which several hundred horticultural varieties are now described, came into domestication because the Old World plums, with which we are chiefly familiar in the Northeastern States, will not thrive in the prairie States or the South. The cultivated native plums had been widely disseminated before horticultural annalists discovered the fact; and there is no evidence that the early introducers of them had any suspicion that they were making history when they planted them. These plums were, no doubt, looked upon as a makeshift in a new country, as a fruit which was better than none when the good could not be had.

The reason why the native raspberries came into cultivation was because the European species is tender in our climate and demands too much care and petting to make it succeed. The native types of gooseberries drove out the foreign ones because the latter were injuriously infested with the mildew. The native crab apples are now demanding attention where the climate is so severe that the cultivated apple can not thrive. The wild red mulberry has been improved because the Old World black mulberry is tender, and we have been so ignorant of the fact that we have all along supposed that these natives are forms of the Old World species. The Chilean strawberry—the foundation stock of our commercial varieties—brought itself into domestication while men were bent upon impressing the Virginian berry into service, and many of our writers still insist on calling the common garden strawberries descendants of the latter species, so ignorant are they of the true course of the evolution.

The obverse of this picture is likewise instructive in showing how difficult it is to introduce and to improve fruits which are not forced upon us. For a century or more the native nuts have attracted the attention of economic writers. Their merits for food have been praised without stint for years and years. Within the last twelve months two nut-culture books have been written. Yet, they have made very little progress toward amelioration. The simple reason is that we have not been pressed by any necessity to grow them. None of the nuts are staple articles of food among the peoples who have chiefly settled the United States. They are essentially subsidiary and incidental features in our lives. So, while we all like hickory nuts and walnuts, we are nevertheless not impelled by any overmastering necessity to gather the trees into the garden or the orchard. We associate them more with the woods and the landscape and the outings

than we do with the kitchen and the larder. They have no conspicuous places in our heritage of custom and association, as the apples and grapes and berries have.

Much the same observation could be made respecting the native huckleberries, fruits which have been recommended time and again as proper subjects for amelioration, and yet practically nothing has been done toward their improvement. The chief reason of this neglect seems to be that the imperative needs which the huckleberries may be supposed to satisfy are already supplied in large measure by other berry-like fruits.

There are apparent exceptions to all this in the cranberry and blackberry, for neither of these fruits has ever before been an important food for the human race. Yet, the very abundance of these fruits and their adaptability to the common needs of life forced them on the attention of the settler and colonist. It was but natural that, as the wild areas became constricted, attempts should be made to grow the plants.

The minor small fruits which have recently come into notice from the West have been chiefly impressed into domestication because of the comparative scarcity of domestic fruits in the regions whence they come. Some of these are the buffalo berry, the dwarf juneberry, the Crandall currant type, and the dwarf cherries and plums.

While the fact has been that the reigning types of improved native fruits have come into cultivation largely as a result of the force of conditions rather than as a direct or designed choice on the part of man, it nevertheless does not follow that an intelligent choice of species has not played an important part in the evolution, and that it may not count for still more in the years to come. Yet, the student should bear in mind the fact that all the most needful types of native fruits have now been impressed into cultivation, and that those which yet remain in an almost wholly unimproved condition, as many of the nuts, the elderberries, the Asimina, and others, will come into cultivation, if at all, only through the expenditure of great effort to make their merits and possibilities known. From now on the attempt to introduce new types of native fruits must be, broadly speaking, a forced effort. But if this is true, it does not follow that our efforts at amelioration should cease, but rather that the most promising and most useful expenditure of energy is to be found in still further improving the species which are already thoroughly established in cultivation. None of these types are yet, and in fact never will be, brought to that condition when they may be said to be good enough; and this conclusion, while apparently the only logical one, is one which does not seem to have been reached by writers upon the improvement of our native fruits. The tendency of our writers has always been, unfortunately, to urge the importance of undeveloped species, forgetting that the really important things are the ones which we already

have, and all of which are far from perfect. The whole question, then, is simply that of the best methods of improving fruits in general without respect to their nativity.

Having now seen that new types of plants are impressed into cultivation largely because they are needed, and in an undesigned or almost fortuitous way, let us ask how these particular domestic fruits which are native to North America have been ameliorated. The process has been a most simple one: Attractive varieties, or forms, have been found, and men have transferred them to the garden. This, in essence, has been the method of the amelioration of most domestic plants. It is first the discovery of a good form, and then the perpetuation of it. What has been called plant breeding is mostly discovery, or, in other words, so far as the cultivator is concerned, it is accident. In one place, an attractive wild blackberry is found. The bush is taken to the garden, and it is called, after the name of the town, the Dorchester. In another place, another form is discovered, and this, when transplanted, becomes known as the Lawton or New Rochelle. Another form is found upon the prairie and is called Western Triumph. Now and then one comes up about an old plantation and is similarly cared for; occasionally a man sows seeds and picks out a good variety from the seedlings; still more rarely a man keeps a record of the parentage of the seed he sows; and very, very rarely one makes crosses and sows the seeds therefrom.

But, while the new varieties are mostly discoveries, it does not follow that there is no skill represented in novelties. The skill is expressed in giving the plants the very best of care when once they have been transferred to the garden, and the force of this domestication is likely to express itself in better or more tractable offspring in each generation. While the tendency toward betterment is constantly augmented by the habitual selection of the best new forms, that tendency could be much more rapidly hastened if, in addition to selecting the best seedlings which chance to appear, the operator should also select the seeds from the best plants with which to raise the seedlings.

It is interesting to recall how a few prominent varieties of native fruits have originated. The old Alexander, or Cape, grape, which first introduced a successful viticulture into eastern America, was found wild in the woods of Pennsylvania in the last century. The Catawba, which is still a popular commercial variety, was found in the woods in South Carolina in 1802. There are, no doubt, as good forms of the native fox grape in the woods now as there were then, but we have now obtained a start in grape growing and we are no longer looking to the wild for our varieties. The fox grape is known to be widely variable in its wild state, and the author has this year obtained no less than a half dozen types of large and handsome wild fruits of it, varying from deep purple to amber red. The Concord was a chance seedling in a Massachusetts garden, and it is supposed to have sprung

from a seed of the wild fox grape of the neighborhood. The Worden was raised from a seed of the Concord. The Delaware was found in the garden of a Frenchman in New Jersey, about fifty years ago, but its genesis is wholly unknown. It is probably a product of an accidental cross between the European grape which the Frenchman cultivated and some variety of native grape. The Brighton is the product of a hand cross made between the Concord and the Diana-Hamburg (the latter itself a hybrid) by Jacob Moore, then of Brighton, N. Y. The Diana, which was a prominent variety for many years, was grown from a Catawba seed in Milton, Mass. Moore Early was grown from a seed of the Concord. The Clinton came up where a handful of grape seed had been sown at Hamilton College, Clinton, N. Y., and the old vine, now about 75 years old, is still growing on College Hill. The Norton Virginia was found wild in 1835, near Richmond, Va. The Isabella was brought into the North early in the century. Its origin is wholly unknown and has been the subject of much speculation. The botanical evidence shows that it is probably a native form of the Southern fox grape.

All these specific illustrations of the origin of varieties are fairly typical for all native fruits. Most of the forms are random or chance discoveries, and they show that the natural tendency toward progressive variation in the indigenous fruit species must be great, else the domesticated forms could not have reached their present state. If so much has been done by mere chance, so far as the horticulturist is concerned, there is certainly reason for believing that the rewards of plant breeding must some day be great.

WHAT PROBABLY SHOULD BE DONE.

What has been done need not be done over again. That is, the best results in the amelioration of any species are to be expected by working with the highly improved forms rather than with the original wild stock. The quickest response to the plant breeder is to be expected in those species which are already most ameliorated, and it is in these species, also, that the greatest efforts are needed, because they are the species which have the most useful qualities for man. One can not specify how the native fruits may be improved without going into the whole subject of the amelioration of plants,[1] but it may be useful to designate some of the things which seem necessary to be done.

In the first place, we need more varieties of every native fruit now cultivated—of grapes, raspberries, plums, cranberries, and the rest. This is because new needs are always arising and the fruits are being grown in new regions, and new varieties are needed to adapt the species to these new wants. Those persons who are looking for the

[1] This subject is fully discussed in Plant Breeding, by L. H. Bailey.

coming of the perfect all-around variety are behind the time and are constantly getting further behind, for it is becoming more and more apparent that it is impossible to combine all the varied and contradictory specific desires of men into one plant form. There must be a best variety for every particular use and locality and soil. The cosmopolitan variety must become more and more restricted in range and usefulness as time goes on and as more refined and specific needs arise. People are always saying that we already have too many varieties, and an effort is being made to reduce the number. Even the experimenters in the stations usually conceive it to be a part of their duty to endeavor to reduce the number of varieties; but what they are really doing, or might be doing, is determining the merits of varieties for specific uses. If a given variety does not satisfy the ideal of the experimenter, that fact is no proof that it may not satisfy the ideal of someone else, or that it may not be a positive acquisition in some other place or for some other purpose. We shall always need to test varieties, to be sure, and the testing must be the more exact and personal the more critical we become in our demands. It is out of the many new varieties that we shall find the particular ones which we ourselves desire.

In the second place, we need a greater range of variation—more divergent and widely unlike varieties. These can be had by selecting out of the annually recurring batches of new varieties those which are most unlike the existing types, provided, of course, they are worthy to be perpetuated. But they can be most surely obtained by raising seedlings from the most unlike types and by the crossing of various types.

In the third place, we need to secure more incidental or minor strains of the most popular and cosmopolitan varieties. The Concord grape, for example, is a most virile and useful type, and minor varieties of it, even if they were still called Concord, might adapt the variety more completely to some particular purpose or locality. In many districts, for example, a Concord a week earlier or a week later than the standard variety might be more useful than a variety wholly new in kind. This class of facts is introduced to show that, while we need more varied types in our native fruits, we also need to increase the usefulness of regnant types by inducing secondary variations in them. There are two means of securing these variations. The surest means is to take cuttings or buds from those particular plants in our plantation which most nearly fit our purposes. In almost every large Concord vineyard, for example, there are some vines which are earlier or later, more or less productive, or otherwise different from the type. In many cases the cuttings will perpetuate these differences. The second means of securing these incidental forms is by crossing between plants of the same variety. The writer is convinced that this type of plant breeding is, in general, quite as useful as that of crossing unlike

varieties; and after a wide range of variation has been secured and when men's ideals have become critical through education and business competition it will be the more promising field.

In the fourth place, it should be said that the greatest effort should be made to preserve or intensify those desirable attributes which are characteristic of the wild species. Such attributes are likely to be more virile and permanent than similar ones which originate under domestication, because they have been impressed upon the species for a longer period of time. The intending plant breeder can save himself much time and strength by throwing his own efforts into line with the direction of evolution of the species rather than against it. He can not afford even to be indifferent to the natural capacities of the type. For example, other things being equal, the domesticator will generally find better results in breeding plants for a dry region by selecting those types which naturally grow in such regions. The adapting of the grape to limestone soils can no doubt be more quickly accomplished by endeavoring to breed up acceptable varieties from *Vitis berlandieri*, which thrives in these lands, than by attempting to overcome the pronounced antipathies of the *Vitis labrusca* types to such soils. The first attempt in impressing new fruit species into cultivation should be to secure a type which will thrive in the given region; the production of ameliorated varieties is a secondary and usually a much simpler matter. The first consideration in breeding plums for the dry plains regions, for example, is to secure a type which will endure the climate—the long droughts, the severe winters, and the hot summers. This fundamental desideratum should be looked for in the indigenous plums rather than in the domestic types. One of the most promising lines of effort in the improving of the native fruits is to work with the species which are indigenous to the locality, if they possess coveted features and if they are naturally variable.

All this means, as has been said, that there should be a general improvement all along the line in our native fruits, the same as there should be in any other fruits; and the greatest improvement is needed in those very types which are already most improved. In other words, we need more to augment the amelioration of types already domesticated than to introduce wholly new types, although this latter enterprise is also of the greatest importance. The new types may be expected to come into use as the demand for them arises, and they will come in gradually, and obscurely at first, as the other types have.

The grape, in the estimation of the writer, needs the first and the greatest attention. The types which we grow are still much inferior to the Old World types. Our commercial varieties, like the Concord, Worden, Catawba, Niagara, Norton Virginia, are generalized types, and the market is now overrun with general-purpose grapes. We shall soon be driven into specializations in grapes, as people have in older

countries, and special varieties will then be needed. Aside from the further improvement of the domesticated native species, we are now being driven, by the settlement of the South and West, to the improvement of other species, as *Vitis lincecumii*, *Vitis champini*, and the like.

The second greatest need is in the development of our native plum flora; the third is in the further evolution of the brambles, like the raspberries, blackberries, and dewberries; the fourth in the amalgamation of the Western crab apples with the domestic apples, for the plains and the Northwest. Beyond these four emphatic needs, it is believed there are none which stand out clearly and unmistakably above all others, although there are a score of native fruit types which are crying out for attention. Among them may be mentioned the chestnuts, pecans, gooseberries, currants, cranberries, huckleberries, juneberries, cherries, mulberries, elderberries, and all the tribes of hickory nuts and walnuts.

The stimulus of the improvement will be found in the increasing demands made by a high civilization, and the actual work of improvement will be done by a few patient souls whose love of the work far outruns all desire for applause or pecuniary reward.

THE SUPERIOR VALUE OF LARGE, HEAVY SEED.

By GILBERT H. HICKS and JOHN C. DABNEY,
First Assistant Botanist and Assistant, Division of Botany, U. S. Department of Agriculture.

INTRODUCTION.

No farm practice yields more beneficial results than the careful and intelligent selection of seed for sowing. The planter who raises a special crop like tobacco, cotton, wheat, or corn usually looks carefully to the quality of his seed, while the truck farmer is even more particular in this respect, paying a very high price for the best obtainable article. Nevertheless, it is true that in general practice, especially in the case of garden and forage plants, there is frequently very slight attention given to the real worth of the seed used for planting, and not infrequently the grower sells his marketable alfalfa or clover seed, for instance, and reserves the remainder, consisting possibly of screenings, for his own use. The folly of such a proceeding can not be too strongly condemned. Weak or otherwise inferior seed, if it comes up at all, often gives rise to sports and new varieties, and so far may be valuable for experimental use; only the very best seed, however, should be employed in the production of staple crops. Any other practice is poor economy. The grades established for clover and grass seed, known as "prime," "choice," "extra prime," etc., take into account only its purity, that is, its degree of freedom from chaff and dirt, weed seeds, and other foreign matter. The buyer is assured in the most general terms (but not guarantied) that the seed he gets is "pure, reliable, and true to name," and selected (by the seedsman) with "reasonable care." No intimation is given, however, as to the proportion which will germinate. It is assumed that any deficiency in this respect can be readily overcome by sowing an extra amount. The still more important points as to the origin, size, and weight of the stock are seldom taken into account.

Another serious drawback to the selection of good seed is the common practice of waiting until about time for sowing before buying. It is then too late to ascertain its origin and history or to test its vitality, even if the planter had a desire to do so. If the cultivator would secure the best possible results from his labor, the seed should be bought by sample in the fall or winter before planting. First of all, it should be examined for purity, and then a simple home germinating test should be conducted. If the sample is pure and of good germinating capacity, the purchase may be completed, after which a careful sorting should be made preparatory to planting in the spring.

PRINCIPLES GOVERNING SEED SELECTION.

The principles governing seed selection depend largely upon the kind of seed and the object of the crop, whether size, quality, or earliness of the latter is most desired. It also makes some difference whether the plants are to be grown for forage or seed. Certain climates, soils, and fertilizers tend to seed production rather than to vegetative development, and a plant may be cultivated and selected for its seed-producing capacity until a strain of seed is obtained which tends to yield plants possessing similar seed fertility. If quality rather than quantity of crop be the object, the selection of seed must follow a certain line in order to secure plants of the desired characteristics.

Seed may be selected according to its origin, color, form (considering especially whether it is plump or wrinkled), size, and weight, it being taken for granted that the selection shall be made only from sound, pure, and germinable stock. It is thought by some that the value of seed varies in certain cases according to the part of the plant or fruit from which it comes. An experiment made in Georgia with cotton showed that the bottom bolls produced seed which gave a heavier yield than that from the upper bolls, the yield in the former case amounting to 1,043 pounds of seed cotton per acre as compared with a yield of 750 pounds in the latter. This was undoubtedly due to the fact that the lower bolls contained larger and heavier seed, rather than because the seed came from a certain part of the plant. Many trials have been made of corn selected from the tips and butts of the ears. Sometimes one and sometimes the other kind of kernels give the best crop. It is quite likely that this variation results from the difference in size and weight of the different kernels taken from the same ear. In the case of the parsley, carrot, parsnip, and other umbelliferous plants, it is commonly supposed that the central stalk produces the best seeds. This may be due to the fact that such seeds are frequently larger and heavier than those from the lateral shoots.

The degree of maturity of seed when harvested is an important factor in determining its value. Many experiments have been made with immature seed, resulting in the conclusion that such seed produces as a general thing smaller and less vigorous plants. Professor Goff, of Wisconsin, has shown that by the use of immature tomato seed there is also a tendency to increased earliness in the maturity of the fruit. By means of continued seed selection, plants may be so developed as to show a certain flavor, capability of resisting disease, general hardiness, earliness, superior content of sugar, oil, starch, gluten, etc.

METHODS OF SELECTING SEED.

The manner of selecting seed varies somewhat with its shape, weight, and size. If heavy seed is desired, a salt solution may be used, of such density that only seeds of a desired weight will sink to the bottom,

while all the lighter seed and undesirable matter can be skimmed off and rejected. This method is open to several objections, among them being the fact that the heavy seeds do not always sink, owing to bubbles of air which surround them or to the flat surface which some species present. This, however, may be obviated to a slight extent by previously boiling the water of which the solution is made. Furthermore, unless dried promptly or sown at once, such seeds may lose some of their vitality. A better way to obtain heavy seed is by making use of the centrifugal principle, applied by running the seed through some kind of apparatus which throws the heavier seed to a considerable distance, while the lighter seed and chaff drop near the machine. By the use of a current of air the same separation may be secured, in this case the lightest material being blown away. The common method of selecting large seeds is by the use of sieves, either by hand or placed in any common fanning mill.[1]

The principal object in using the ordinary fanning mills is elimination of chaff and other foreign matter, although some of the lightest seed is blown out by the fans. It would pay the farmer when he is cleaning up seed for planting to work his seed-cleaning machines in such a manner as to blow or screen out a great deal of the light and small seed, retaining only the largest and heaviest for planting.

Seeds are sometimes cleaned and sorted by running them through a thin metal cylinder placed in a slightly inclined position. This cylinder is provided with a series of holes of different shapes and sizes, which allow certain seeds to drop through at certain points. Machines embodying this principle are used considerably in Europe and to a small extent in this country.

The fact needs emphasis, however, that no system of seed selection by mechanical means alone is adequate, although such selection, if properly practiced by the agriculturist, would invariably bring him a decided gain in the size or quality of his crop. Thorough selection must begin with the plant itself. Only those plants should be chosen for seed purposes which come the nearest to the type which is to be reproduced. Such plants are to be harvested and kept by themselves. After their seed is thrashed and cleaned, another and rigid selection, based upon size and weight, should be made.

DESIRABILITY OF KNOWING THE ORIGIN OF SEED.

In the choice of seed the place of its production should receive very careful consideration. Much of the failure to secure a desired crop of vegetables or forage plants is due to the fact that the buyer of such seed usually has no information whatever as to its origin. The soil and climate where it was produced may have been very different

[1] See Yearbook of the U. S. Department of Agriculture, 1894, pp. 406–407, for brief description, with figures, of different kinds of screens in use.

from his own, and the seed be totally unfit for use on this account. A great deal of controversy has arisen from time to time over the alleged superiority of Northern-grown seed, and many dealers make a great point out of the statement that their seed is Northern grown. This is not a question of section alone, nor is it true that Northern-grown seed is always superior to that raised in other latitudes. As is well known, certain plants thrive better in one locality than in another. Plants adapted to Northern climates or high latitudes where the seasons are short mature more quickly than if grown under different conditions, and hence yield a strain of seed which in time tends to produce quickly maturing plants. However, such seed frequently "runs out" quickly when planted in a different climate and gives rise to very different strains from the original stock; hence, a constant renewal is necessary to maintain the type desired. In many cases by a system of careful cultivation and selection a desired strain may be secured and thoroughly acclimated, so that the introduction of outside stock becomes unnecessary. The fact that many kinds of imported seed do not produce as good crops as home-grown seed of the same variety is to some extent due to a difference of climate. The imported seed, while perhaps cheaper in the first instance, owing to the less cost of production, may be much dearer in the long run, since it is seldom so pure as American-grown seed, and frequently gives rise to noxious plants which the buyer neither desires nor pays for.

Soil, as well as climate, impresses seed with a particular character. It is not necessarily the most fertile soils which furnish the most productive seeds. If seeds are transferred to a different kind of soil from that upon which they were grown, although the climate be the same, a marked difference in crop is frequently noted. Experiments in growing oats have shown that certain varieties raised on a light soil were the most productive if sown on a similar soil, while the same varieties of seed if grown on heavy soil showed a preference for heavy soil. These facts indicate that, in many cases at least, the farmer will get the best results from seed which he has grown himself under conditions well known to him.

The Department of Agriculture frequently receives requests from European seedsmen for seed of various kinds raised in a part of the United States the climatic and soil conditions of which correspond most nearly to those of their own localities, thus showing an appreciation of the value of a knowledge of the origin of seed. Most of our own seedsmen show a similar interest in knowing where their seed was grown. Unfortunately, however, this interest prevails at the present time among the buyers of seed only to a very limited extent. The farmer should secure from the dealer whenever possible a statement of the origin of the seed which is offered for sale. Until such requests become much more common than they are now, seedsmen

will continue to offer seed accompanied by no information save its name and brief directions for planting.

Seed should be selected with reference to its ancestry as well as to the place and conditions under which it was grown, or its individual characteristics. Plants, no less than animals, inherit the qualities of

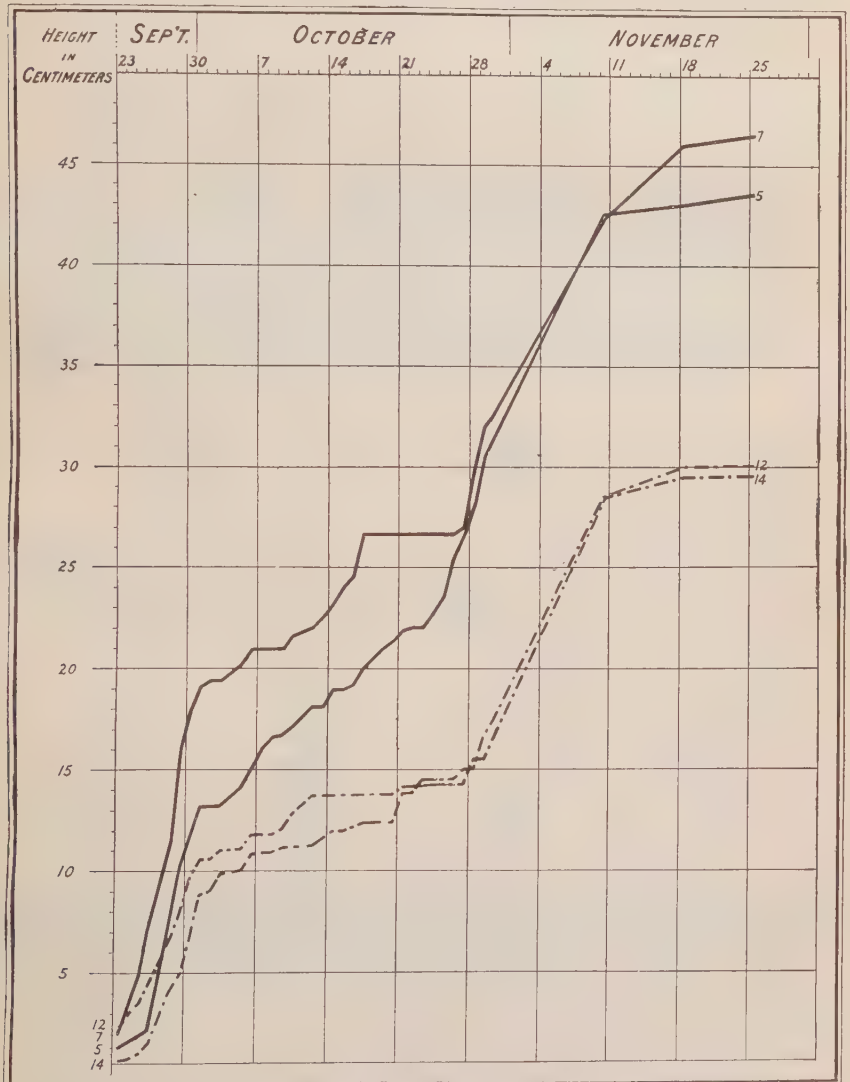

FIG. 74.—Development of soja bean from heavy and light seed: The upper curves represent plants from heavy and the lower those from light seed.

their forerunners, and this applies to seed as well as to the plant taken in its entirety, especially if grown for seed alone, as in the case of the cereals and some legumes. Unfortunately the ancestry of seed can rarely be traced by the purchaser.

The main purpose of this article is to show in a brief way the advantage of using only large and heavy seed for planting, and, if possible, to establish the principle that it will pay in many cases to buy a larger quantity of seed than is to be used, in order that only a larger and heavier seed may be selected for planting.

FIG. 75.—Soja bean, 12071 (heavy compared with light seed): A, planted September 15, 1896, photographed October 15, 1896; plants in rear pots from heavy and those in front pots from light seed. B, four typical plants photographed at the close of the experiment, the two at left from heavy and the two at right from light seed.

MANNER OF CONDUCTING SEED-SELECTION EXPERIMENTS.

The series of experiments upon which this paper is based were conducted in a greenhouse by the writers during the winter of 1896–97. Seeds of the following plants were employed: Garden peas, beans, soja beans, hairy vetch, rye, barley, wheat, and oats, the three first named being principally dealt with here. In all cases except that of the hairy

vetch the seed was of known origin, each variety having come from a single lot grown in one place. We consider this fact one of the most important conditions of the experiment. In many experiments on record of somewhat similar nature no mention is made of the origin of the seed, which is generally of the ordinary commercial kind and often a mixture of various lots grown under different conditions. The results obtained from such seed can not be relied upon.

The seed was carefully separated into two lots, one of heavy the other of light seed, the individual seeds of each lot having approximately the same weight. These seeds were planted in pure sand, and the plants were given equal amounts of a culture solution which con-

FIG. 76.—Seedlings from heavy and light seed: I, Vicia faba, 12072. Weights: A, seed, .847 gram; plant, 11 grams. B, seed, .389 gram; plant, 6.5 grams. II, Soja hispida, 12071. Weights: A, seed, .164 gram; plant, 1.5 grams. B, seed, .120 gram; plant, .7 gram.

tained all the necessary elements of plant food. They were kept from first to last under identically similar conditions so far as possible, measurements and photographs being made from time to time. At the conclusion of each experiment typical plants from each lot were photographed, carefully taken from the soil, weighed, and measured.

EXPERIMENTS WITH SOJA BEANS OF DIFFERENT WEIGHT.

The table following shows the comparative growth of soja beans from heavy and light seed. The seed used in this experiment was raised at the Massachusetts Agricultural Experiment Station. It was planted September 15, 1896, and harvested December 12, a growing period of eighty-eight days.

Development of soja bean from heavy and light seed.

(*a*) FIVE HEAVY SEEDS.

Number of plant.	Weight.[1] Seed.	Root.	Shoot.	Plant.	Height of plant.	Number of leaves.	Length of taproot.	Diameter of stem.
	Grams.	*Grams.*	*Grams.*	*Grams.*				
		(0.7)	(3.3)	(4.0)	*Mm.*		*Mm.*	*Mm.*
2	0.189	4.8	8.6	13.4	352	17	220	4.0
		(.6)	(6.7)	(7.3)				
5	.204	4.6	9.7	14.3	405	19	238	4.0
		(.9)	(3.8)	(4.7)				
6	.201	5.8	9.7	15.5	407	28	215	4.5
		(.6)	(2.6)	(3.2)				
7	.219	3.8	7.4	11.2	415	24	202	3.5
		(1.2)	(6.6)	(7.8)				
10	.197	12.1	19.6	31.7	483	26	198	5.0
		(4.0)	(23.0)	(27.0)				
Total	1.010	31.10	55.0	86.1	2,062	114	1,073	21.0
		(0.8)	(4.6)	(5.4)				
Average	.202	6.22	11.0	17.22	412.4	22.8	214.6	4.2

(*b*) FIVE LIGHT SEEDS.

Number of plant.	Seed.	Root.	Shoot.	Plant.	Height of plant.	Number of leaves.	Length of taproot.	Diameter of stem.
		(0.4)	(2.4)	(2.8)				
12	0.077	3.9	6.3	10.2	261	15	352	3.0
		(.2)	(2.0)	(2.2)				
14	.088	2.0	4.8	6.8	281	13	180	3.0
		(.2)	(.8)	(1.0)				
16	.085	1.2	2.5	3.7	157	11	195	2.5
		(.7)	(4.0)	(4.7)				
17	.076	8.0	11.7	19.7	343	18	375	4.0
		(.4)	(3.0)	(3.4)				
18	.086	2.7	6.9	9.6	344	11	182	3.0
		(1.9)	(12.2)	(14.1)				
Total	.412	17.8	32.2	50.0	1,386	68	1,284	15.5
		(.4)	(2.44)	(2.82)				
Average	.082	3.56	6.44	10.0	277.2	13.6	256.8	3.1

[1] The weights in parentheses are air dry, the others fresh.

A reference to the table shows that the heavy seed (lot *a*) weighed over twice as much as the light (lot *b*), and the resulting plants weighed nearly twice as much in the former case as in the latter.

The development of the soja beans was retarded for a couple of weeks by unavoidable lowering of the temperature in the greenhouse. Afterwards the growth was uninterrupted and the plants at all times were healthy, although the usual somewhat bushy habit of similar plants in the field was not attained. No root tubercles were developed, with the exception of a few on No. 12. The experiment was closed at a time when the plants were in the best condition for forage or green manure, that is, about the time of flowering. It is not known, however, whether this degree of difference would have been

maintained in the open field. Hellriegel claims that the difference between mature plants from large and small seed is greater in impoverished soil than in that which is richly supplied with food material. The difficulty of absolutely controlling the conditions of

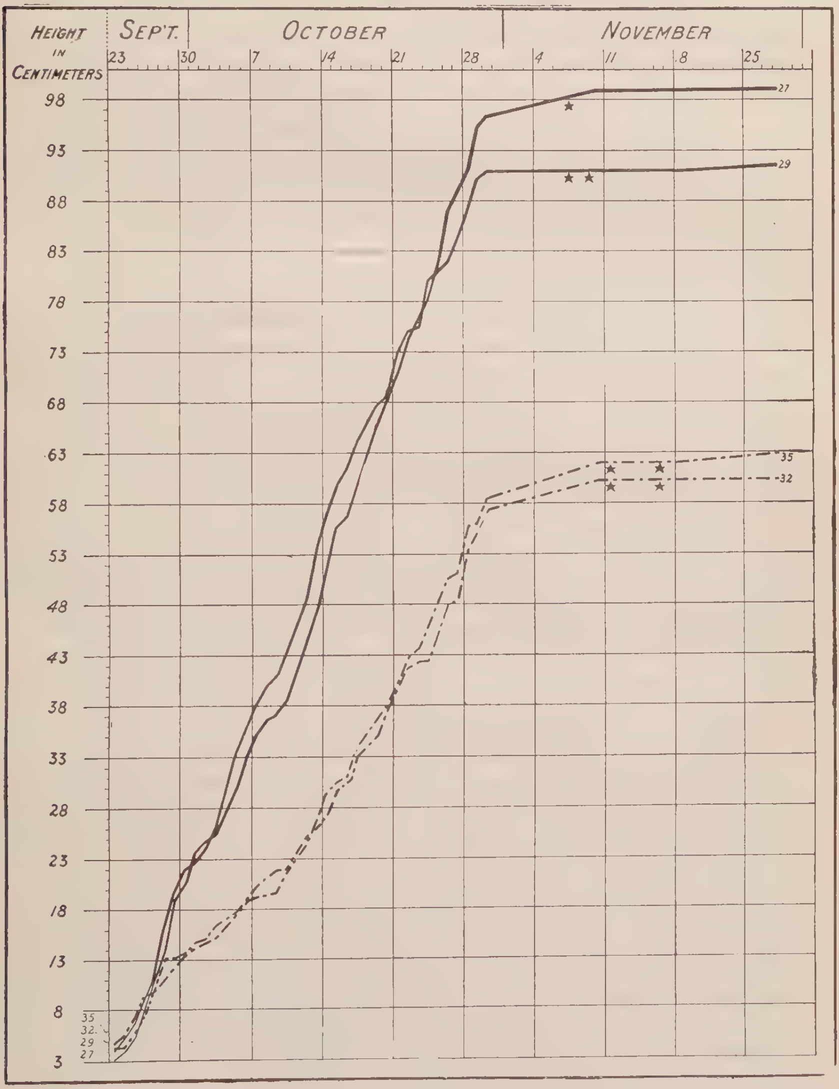

FIG. 77.—Development of Extra Early Alaska peas from heavy and light seed: The stars show when the pods were ready for the table; the upper curves represent plants from heavy seed and the lower curves plants from light seed.

plants in the field makes results from such experiments somewhat uncertain. Although no organized food was furnished to the soja beans in this experiment, an abundant amount of all the elements necessary to plant growth was constantly given them. The plants of

each lot were treated alike and the results obtained hold perfectly good for comparison, although the greenhouse conditions were not as favorable as could have been wished and the total development was much smaller than it would have been in the open field, where it is believed a greater difference would have been shown in the result.

It has also been stated by Hellriegel that the differences in plants grown from large and small (in this case equivalent to heavy and light) seed are most apparent in their earlier stages, growing less marked toward maturity. He further claims that a greater difference at maturity is visible in plants grown in quartz-sand cultures than in those grown in garden soil. The curves shown in fig. 74 are of great interest as bearing on this point. It will be noticed that, while the two plants of each lot maintained an approximately equal growth throughout the experiment, during the early seedling stage—that is, for the first week from the time of planting—the plants from both heavy and light seed showed nearly the same degree of development. From this period the growth of the two lots began to deviate considerably, reaching its widest divergence at the close of the experiment. Fig. 75 is taken from photographs, one made thirty days from the time of planting and the other at the close of the experiment. In both cases a striking difference is shown in the development of the plants from the two kinds of seed. The difference between seedlings of soja beans from heavy and light seed is seen in fig. 76, II, which represents a typical seedling from a lot of heavy and another from light seed. The difference in development is equally apparent in roots, stems, and leaves. A study of the individual plants (see table, p. 312) shows that each plant (fresh) in lot *b* was lighter than any of lot *a*, excepting No. 17. In this case the large weight is unaccountable. The pot in which this plant grew proved to be less porous and hence more retentive of moisture than any of the rest, and to this fact some of the extra vigor may have been due. Plant No. 16, from some unknown cause, showed a retarded development from the first, and was lightest at the close of the experiment. However, the extra development of one plant is nearly offset by the weakness of the other, and the average result is only slightly affected, although the difference in favor of the heavy seed would have been more marked if these plants had not been taken into account. It will be observed that while the weight of each plant is not exactly proportional to that of the seed, there is an unmistakable average proportion maintained in considering the total of each lot.

Plants from the heavier seed were greater not only in weight, but also in length, in number of leaves, and in diameter of stem. Although the average root length was greater in the soja beans grown from light seed, the total root development was much less. The advantage to the heavy seed plants in possessing a greater root development is evident in the fact that such plants have so many more absorbing organs

for taking up the food elements of the soil. Another great advantage, especially while in the seedling stage, is in the better soil grasp afforded to such plants, giving them a firmer hold at a period when the wind or other unfavorable circumstance is most likely to uproot them or lay bare their roots. The greater stem diameter is correlated with a larger number of tubes (vascular bundles) for pumping up the nourishment to various portions of the plant. The larger leaf surface secures greater transpiration and consequently a more rapid food supply, as well as a greater capacity for transforming the raw food materials into the organized substances necessary for growth.

EXPERIMENT WITH PEAS.

In selecting heavy peas for seed the same advantages were attained as in the case of the soja bean, with the addition of a very important factor—increased earliness. The seed used in this experiment was grown on the Department grounds, under conditions of soil as nearly identical as possible. The following table gives the result of the experiment:

Development of Extra Early Alaska peas from heavy and light seed.

Number of plant.	Weight.						Length.		Number of leaves.	Size of pods (combined).			Number of pods.	Number of peas.	Diameter of shoots.
	Seed planted.	Root.	Shoot.	Hull.	Seed.	Plant.	Root.	Shoot.		Length.	Breadth.	Thickness.			
(a) FOUR HEAVY SEEDS.															
25	0.250	3.2	1.0	0.466	1.409	6.075	395	770	12	107	28	18	2	6	3.0
26	.253	2.5	1.0	.385	1.777	5.662	200	890	12	136	41	22	3	9	3.0
27	.274	2.2	1.3	.390	1.723	5.613	280	990	12	108	28	18	2	9	3.0
29	.264	1.2	1.1	.358	1.677	4.335	290	900	12	132	37	23	3	9	3.0
Total	1.041	9.1	4.4	1.599	6.586	21.685	1,165	3,550	48	483	134	81	10	33	12.0
Average	.260	2.27	1.1	.399	1.646	5.421	291	887	12	120	33	20	2.5	8.2	3.0
(b) FOUR LIGHT SEEDS.															
32	0.102	0.8	0.6	0.205	1.075	2.680	222	605	11	96	26	14	2	6	2.5
34	.108	.5	.5	.189	.889	2.078	255	526	11	88	26	13	2	5	2.5
35	.102	1.0	.6	.182	.735	2.517	178	602	11	84	25	14	2	4	3.0
36	.103	.8	.5	.184	.915	2.399	290	748	11	85	24	13	2	6	2.5
Total	.415	3.1	2.2	.760	3.614	9.674	945	2,481	44	353	101	54	8	21	10.5
Average	.103	.77	.55	.190	.903	2.418	236	620	11	88	25	13.5	2	5.2	2.6

NOTE.—The weights are air dry in grams; the measurements in millimeters. Five seeds were used in each lot, but the flowers of the fifth plant of lot *a* were not fertile; hence, this plant is not used in the table. One plant was rejected from lot *b* to make the results comparable.

As will be seen by referring to the table, the peas from the heavier seed made a better growth in every way than those from the light

seed. The seed used in lot *a* was two and one-half times as heavy as that in lot *b*, while the air-dry plants from the heavy seed weighed two and one-fifth times as much as those from the light seed. Thus, it is seen that nearly the same ratio of difference obtains in the total crop as in the seed used for planting. The flowers in lot *a* began to blossom four days earlier, on the average, than the others, and produced the first marketable peas four days earlier. (See fig. 77.) As a crop, the pods on plants raised from large seed were ready for table use from five to six days earlier than those on the plants produced from small seed. This advantage held good for all the plants in the experiment.

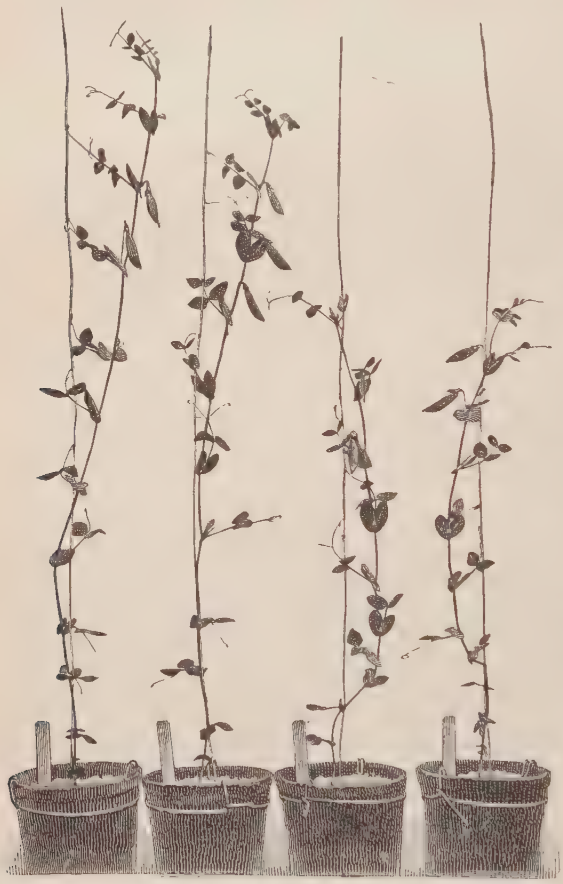

FIG. 78.—Peas, Extra Early Alaska, from heavy and light seed: Plants at the left are from heavy and those at the right from light seed.

The ability to market a crop of peas from four to six days earlier than otherwise possible by merely selecting the heavier seed for planting would be of very great value to the truck gardener and would involve a gain throughout the country of thousands of dollars for those engaged in this industry. No one quality is more sought by the trucker than earliness, and from a financial point of view this is the most valuable characteristic attainable in the production of many kinds of vegetables. A difference of six days in the maturing of peas is almost equivalent to a difference of 100 miles of latitude. While it is true that as great a difference in earliness might not always obtain in general practice, the experiments conducted show conclusively that similar selection of heavy seed peas is worthy of the attention of truck gardeners, and especially of seedsmen who are desirous of originating extra-early varieties.

The use of the larger or heavier peas, however, resulted in an increase of crop as well as in earliness. (See table, on page 315, and fig. 78.) There were more blossoms and marketable pods on the plants from heavy seed than on those from light seed. Furthermore, the weight of the air-dry fruit (pods and peas together) was nearly doubled by the use of the larger seeds. An examination of the soja bean showed that the difference in weight in the fresh state between plants from heavy or light seed was considerably greater than when the same were air-

FIG. 79.—Beans, Extra Early Red Valentine, 11469, large compared with small seed: A, planted September 16, 1896, photographed September 30, 1896; plants in rear pots from large and those in front pots from small seed. B, four typical plants photographed at close of experiment.

dried; hence it is not unlikely that if the peas had been weighed green—that is, as they would have gone to market—the advantage of the use of the heavy seed would have been still more striking.

EXPERIMENT WITH BEANS OF DIFFERENT WEIGHT.

An experiment conducted with Extra Early Red Valentine beans indicated a similar advantage in increasing the earliness by the use of

heavy seed. These plants maintained a marked difference in development from the first. Fig. 79, A, represents their condition two weeks after the seeds were planted. Every plant excepting one from the heavy seed showed a marked increase in size over the plants from light seed at the time this photograph was taken. This difference was maintained until the close of the experiment. (See fig. 79, B.) The difference in vigor was shown also in the greater diameter of the stems, which averaged five-tenths of a millimeter more in each plant in lot *a* than in those in lot *b*.

We are aware that there is a common belief that weak seeds tend to produce earlier fruiting plants than seeds which are more vigorous, but our experiments gave decisive indications that the contrary is true, at least in some cases.

FIG. 80.—Root development of plants grown from heavy and light seed: I, beans, Extra Early Red Valentine; II, peas, Extra Early Alaska. The two roots at the right in each case are from heavy and the two at the left in each case are from light seed.

ROOT DEVELOPMENT OF PLANTS FROM HEAVY AND LIGHT SEED.

The increase in the root development of plants resulting from the use of heavy seed is well indicated in fig. 80, I, which shows the fresh roots of four typical plants of the Red Valentine beans used in the experiment discussed above. The weights were as follows: Fresh roots of plants from large seed, 9 and 17.7 grams, respectively; of plants from small seed, 4.1 and 4.5 grams, respectively.

Not only in weight, but also in length and number, were the roots from heavy seed greater than those from light seed. Neither length nor number of the main roots is of as great importance, however, as the total weight, which indicates not only a greater individual diameter, but also—and this is of much more significance—a vastly larger number of little rootlets and root hairs for absorbing food from

the soil. The weight of the fresh roots from both lots of beans was directly proportional to the weight of the seed, being nearly twice as great in lot *a* from heavy seed as in lot *b*. The comparative devel-

FIG. 81.—Early development of barley from heavy and light seed: Barley, Salzer's, 13093. Planted September 30, 1896, photographed October 14, 1896. Seedlings weighed as follows: A, 39.5 grams; B, 34.5 grams; C, 29 grams; D, 23 grams. Fifty seeds were planted in each lot, weighing as follows: A, 2.522 grams; B, 2.146 grams; C, 1.496 grams; D, .957 gram. Typical seeds from each lot are shown natural size.

opment of roots grown in the same soil and under other similar conditions can not alone be taken as the index of a plant's vigor, but it goes a long way in this direction.

The roots of the peas were not weighed fresh, but when air dried those from the heavy seed averaged 2.27 grams to 0.77 gram in the case of those from the light seed, the seeds averaging 0.260 gram in the former case and 0.103 in the latter. (See table, on page 315.) In

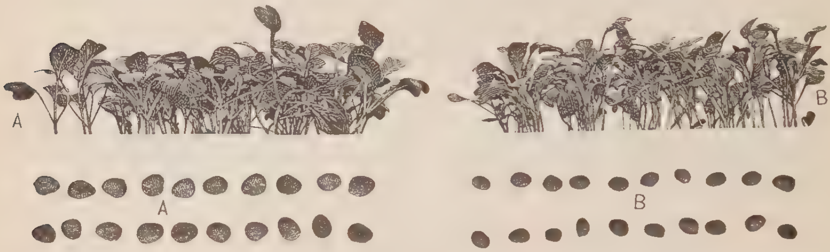

FIG. 82.—Early development of radish from heavy as compared with light seed: Radish, Early Long Scarlet, 11256. Planted October 16, 1896, photographed November 5, 1896. Fifty-eight seedlings of each lot weighed November 9, as follows: A, 49.5 grams; B, 31.5 grams. Typical seeds are shown natural size; A, 100 weighed 1.770 grams; B, 100 weighed 1.037 grams.

other words, the seeds of lot *a* were two and five-tenths and the roots of lot *a* two and nine-tenths as heavy as the corresponding seeds and roots from lot *b*. This difference is strikingly shown in the roots of four typical plants represented in fig. 80, II.

FIG. 83. Early development of kafir corn from heavy and light seed: Red kafir corn, 11704. Planted October 16, 1896, photographed November 20, 1896. Forty seven seedlings of each lot weighed as follows: A, 22 grams; B, 13 grams. One hundred seeds were planted in each lot, weighing as follows: A, 3.398 grams; B, 1.741 grams.

RELATION OF HEAVY SEED TO THE EARLY STAGES OF PLANT GROWTH.

Planters frequently experience difficulty in obtaining a good stand of grain and other crops. Sometimes the seed comes up very unevenly, either leaving certain portions of the field bare or producing plants of

unequal height and vigor. The weaker plants, if they grow to maturity, produce a smaller crop of forage and fruit than those which had an early and better start. Furthermore, the value of the crop is greatly lessened owing to the larger proportion of light seeds and screenings which are rejected when it is offered for sale. Frequently the extra labor and expense of harvesting portions of the crop at different times are made necessary.

A still more serious drawback results from the fact that many weak plants perish in the seedling stage. If any of the seeds are lacking in vigor, even though they may germinate, a sudden change in temperature, or a prolonged drought, or a slight frost is apt to destroy the plants while in their young and tender condition.

Insufficient attention has been paid to the fact that different seeds, even of the same variety and lot, possess an unequal vigor, which shows itself in the plants produced. It should therefore be the aim of the planter to so select his seed that both vigor and uniformity may be secured.

In order to compare the germinative power and stand of plants grown from heavy and light seed, a series of experiments was conducted in the greenhouse, in well-drained shallow boxes (greenhouse "flats") filled with sand, cleaned and sifted. The seeds were first sorted by means of sieves into different sizes and then counted out in lots of 50 to 100, only sound seeds being taken. They were next weighed, photographed (natural size), and planted, both the heavy and light seed being in the same box. All the seeds of a single variety were covered with the same depth of sand and were kept under similar conditions throughout the experiment. Equal amounts of the same food solution were given them from time to time. A record was also kept of the germination. At the close of the experiment, which ceased before the plants had grown beyond the seedling stage, they were photographed, then taken out of the sand, cleaned and weighed while still fresh. Radish, amber cane, red kafir corn, barley, sweet pea, winter vetch, oats, and rye were used in this experiment. The differences in the comparative size of the seeds and seedlings is illustrated by figs. 81, 82, and 83, taken from photographs. The results of the experiments are given in the following table:

Experiments with heavy and light seeds.

Name of variety.	No. of seeds in each lot.	Weight of seeds.	Number germinated.	Number of plants weighed in each lot.	Number of days of experiment.	Weight of seedlings.
		Grams.				*Grams.*
Radish, Early Long Scarlet	100	A 1.770	A 73	58	24	A 49.5
		B 1.037	B 84			B 31.5
Cane, Early Amber	100	A 2.411	A 43	43	40	A 23.5
		B 1.360	B 48			B 12.0

Experiments with heavy and light seeds—Continued.

Name of variety.	No. of seeds in each lot	Weight of seeds.	Number germinated.	Number of plants weighed in each lot.	Number of days of experiment.	Weight of seedlings.
		Grams.				*Grams.*
Kafir Corn, Red	100	A 3.298	A 90	47	39	A 22.0
		B 1.741	B 49			B 13.0
Vetch, Winter	50	A 4.077	A 48	47	15	A 33.0
		B 2.099	B 47			B 18.0
Sweet Pea, Her Majesty	50	A 6.092	A 46	41	26	A 58.0
		C 4.045	C 47			C 44.4
Rye, University of Minnesota, No. 2	50	A 1.105	A 45	45	23	A 34.5
		B .745	B 45			B 20.0
Oats, White Wonder	50	A 1.298	A 50	49	23	A 37.2
		B .805	B 49			B 25.0
Barley, Salzer's	50	A 2.522	Not recorded.	Equal numbe of each lot.	19	A 39.5
		B 2.146				B 31.5
		C 1.496				C 29.0
		D .957				D 23.0

NOTE.—A, heavy seed or seedlings; B, lighter than A; C, lighter than B; D, lighter than C.

As will be noticed by a study of this table, there was in every instance a marked increase in the weight of the seedlings from the heavier seed which was closely proportionate to the difference between the weight of the seed. The experiments were too limited in number to warrant any conclusion concerning the difference, if any, in the germinability of the heavy and light seed, either as to the time the sprouts appeared or the number produced. In the various experiments some of the plants were used for other purposes and could not be weighed. The number of seedlings taken into account in the different lots of each variety was the same, so that the results are perfectly comparable. The seedlings from heavy seeds always showed more vigor than those from the lighter seeds, and there seems no doubt that this superiority would have been maintained to a considerable extent in the field. Of the barley, four different sizes and weights were taken and a corresponding gradation was noted in the seedlings therefrom.

Owing to a lack of facilities, these experiments were not conducted on a field scale, but numerous investigators both in this country and Europe have found that heavy seed wheat, oats, etc., produce heavier crops in the field than lighter seed of the same variety sown under similar conditions; and there seems no room for doubt that, in the majority of instances at least, the selection of large or heavy seed will amply repay the planter for all the extra time, labor, and money expended.

TREE PLANTING IN WASTE PLACES ON THE FARM.

By CHARLES A. KEFFER,

Assistant Chief, Division of Forestry, U. S. Department of Agriculture.

GENERAL REMARKS.

This article is purposely confined to the treatment of limited areas of land rather than the planting of waste lands in general, because it is thought that there are very few farms in the United States in which such limited areas do not occur, for the planting of which practical suggestions may be given, while for the larger operations of extensive wastes—such as dunes, sand hills, and deforested mountain lands—the methods of technical forestry are more applicable.

In the most favored region the farm "of which every foot is arable" is seldom seen. Even on the richest of prairie farms the crests of the rolling surface are apt to become impoverished after years of tillage, in spite of the best efforts of the farmer, and when the crops fail to pay for the labor expended on them the land is as surely "waste" as though it were undrained swamp or rocky hillside. In the less densely populated parts of the country, where land is cheap, the fields are abandoned when this stage is reached. In the East and South, that is, within the forest area, where the entire country was once covered with forest, natural reforestation soon takes place, and in a few years the old fields are clothed with pines, spruces, and deciduous trees, the varieties being dependent upon the adjacent growth. Within this area the farmer can always control the character of the forest growths on the waste lands of his farm, either by planting or by use of the axe, or both, and there is oftentimes great need of good judgment in cutting out inferior trees or undesirable varieties.

The farm is to be regarded as the capital of the farmer, which is invested at its best only when every acre is producing the most valuable crop in the greatest quantity of which it is capable. Unproductive land is as surely "dead stock" as unsalable merchandise, and just as the merchant finds a higher rate of profit in some lines of trade than in others, so the farmer finds certain fields more profitable than others. Both merchant and farmer are forced at times by the exigencies of business to continue the less profitable investments, and he is most successful who turns them to the greatest possible account.

The thin-soiled ridges of the farm, covered, as they may be, with forest growth, fulfill a threefold purpose: they form a wind-break to the adjacent fields, increasing thereby their productiveness; they hold the drifting snows, and insure their slow melting, thus prolonging the

opportunity for absorption of the snow water by the adjacent fields of lower elevation; and they prevent late and early frosts by creating air currents and controlling their direction.

Few farmers seem to have realized the great value of a close-planted, thick-foliaged grove as a conservator of moisture. The effectiveness of a wind-break depends upon its location, density, extent, and height. Well-planted groves, set thick at the borders, especially with coniferous trees, located on the crests of the ridges in the prairie farms of the Mississippi and Missouri valleys, would do much toward breaking the force of the winds which blow so constantly, protecting the crops on the sheltered slopes and forming protected runways for stock in winter. The snows accumulating in such groves are shaded from the sun, and long after the adjacent fields are bare the snow is slowly melting and the water trickling down over the plowed fields, which are thus thoroughly saturated.

It is not to be supposed that limited plantations, confined to the waste places of the farm, would have an appreciable effect on the general climate of a region, for the influences must be great that can affect atmospheric conditions over a wide area. Locally, however, the planting of hilltops and the consequent heightening of elevations will often result in the creation of air currents that will prevent cold air from settling in the lowlands between, thus obviating late spring and early autumn frosts, and this protection can be made more efficient if the configuration of the neighboring lands be studied with a view to creating the strongest possible draft.

In regions where tender vegetables and fruits are largely cultivated such protection may be of primary importance, and the clearing of adjoining hill crests and slopes will often result in serious disturbance of the local climate.

The great utility of forest plantations in saving snow water to the adjacent fields has been mentioned. The summer rains are also saved to the farm by the same means. Following the deep-descending roots of the trees, they are retained in the lower strata of the soil and then pass to the adjoining lands and are brought within reach of the growing plants. Such plantations are beneficial also in checking evaporation from the growing crops by breaking the force of the wind. This utility is of the utmost importance in the Western States, where there are no natural groves except near the rivers.

Situated on the crests of slopes whose sides, together with the lowlands between, are under tillage, a forest plantation has much greater value as a wind-break than where the order is reversed, or than on level ground. As the winds are in general parallel to the earth's surface, any obstruction which turns them upward on a rising slope will protect the land beyond such slope. The matter of protecting a crop at crucial periods of its development is a vital one in Western farming, where it not infrequently occurs that hot south winds sweep over the

country while the grain is in the milk or dough stage and completely ruin it. Instances of fields protected from such storms by well-grown forest plats are not uncommon. Windstorms of great severity are also of frequent occurrence in the spring, when the young grain is literally twisted off at the surface of the ground or the soil is so blown away as to expose the roots. It is as a protection against such storms that the planting of thin-soiled ridges and fence lines and of the portion of the section-line highways not needed for the purpose of travel is urged.

In general, the climatic conditions of the forested area of the country are less extreme than those of the plains, but with the record of the three recent drought years the need of moisture conservation is apparent alike in the East and West.

While in the West the thin-soiled ridges are best devoted to tree growth for wind-breaks and snow catches, throughout the Eastern and Southern States such localities should be kept in trees for the prevention of erosion or gullying, one of the most troublesome results of tillage.

The general action of the elements in uneven or rolling surfaces invariably tends to carry the more fertile top mold of the higher ground, or at least the decaying vegetation on the surface, to the lower levels, which thus relatively increase in fertility at the expense of the elevations above them. In addition to this general tendency there have been deposited throughout the Northwestern States, by glacial and water action, drift soils containing a great quantity of bowlders, which are especially thick on the high ridges, making their cultivation very expensive. In many localities throughout the Mississippi Valley the trend of the underlying strata of rocks is upward, often coming so close to the surface in the ridge lands as to render them worthless for cultivation. Along many river and creek valleys the hills which confine the lowlands rise so abruptly as to make cultivation impracticable. These and many other special cases which might be mentioned constitute the waste highlands of farms, all of which should be devoted to forest-tree culture.

Trees, as has been seen, can exist and make a profitable growth on lands too poor to support farm crops. When planted in the thin soil of a limestone hill crest, they may make very slow growth during the first few years; but as the soil becomes shaded by the tree tops the growth becomes more rapid, and when the trees have attained a strong foothold, their roots penetrating the crevices of the rocks to the water below, they grow with additional vigor.

Yet, it is not to be expected that as vigorous growth can be secured in these high waste places as in the lower, moist, and deep soils. Because the white cedar, the cypress, and the tamarack are found in swamps, where the surface of the soil is under water more than half the year, it does not follow that this is the ideal condition for them;

neither must it be thought because scrubby red-cedar trees find a lodgment in the limestone outcrop of the Kansas River bluffs that such sites are the best for their growth. Such instances only prove the great capability of trees to endure adversity, and show that there are few waste places in which they can not grow.

One has only to recall the general character of the waste places of the farm to realize how little can be gained from cropping them. The ridge soils are too thin to support a growth of cereal crops; the swamp soils are too wet for tillage; the cultivation of irregular plats of small extent becomes too expensive, by reason of the difficulties of plowing, seeding, and harvesting. Once in trees, these difficulties are reduced to a minimum. The thin soils of the ridges are protected from the weather by the tree crowns, and their decaying foliage gradually increases the fertility of the soil.

Of the planting of swamp lands on the farm, little need be said, for the reason that such lands, properly drained and managed, are too valuable for tillage to be used for tree culture. There is deposited in them not only the decayed vegetation by which they have been covered for hundreds of years, but also much of the fertile materials which the descending waters have brought from the higher levels. If, however, drainage is impossible, such land is much better covered with trees than standing idle. Throughout the irrigated districts of the West many places also are made too wet for tillage by seepage from the ditches. Such places, if properly underdrained, may be continued in cultivation without especial difficulty, but if for any reason drainage can not be accomplished the "seepage spots" can be profitably planted to trees.

The odd corners and fence rows of American farms represent in the aggregate a great quantity of unproductive land, which might be planted to trees. Such limited areas, often composed of but a few square rods or very narrow strips, can not be treated as forest, but trees must be grown on them for special purposes, in which timber production will hardly be considered.

The highways throughout the farming districts of the United States may be bordered with trees, which, while giving shade, may be used as living fence posts, or may become valuable nut orchards, but in any event will afford protection, in winter and summer alike, to the traveler and to the adjacent fields. In Minnesota, Wyoming, and other Western States the highways are at least 66 feet wide, and often a hundred. These tracts, separated only by wire fences from the cultivated fields, are not merely waste lands, but, for the most part, veritable propagating beds for noxious weeds, which cause much loss to the farmer. Try as he may, he can not protect his lands from Russian thistle, mustard, and the numerous other weed pests so long as these broad highways exist as a seeding ground for them. If they were planted to trees, with a vigorous undergrowth to protect the

surface of the soil, they would not only make any weed growth impossible, but would also be a potent means of preventing the dissemination of weeds from one section to another, by arresting them when carried by the winds. In many of the Western States the farmer is permitted by law thus to plant a portion of the highway with trees.

Yet, another form of waste land is to be considered; and here the farmer living within the forest area is much more concerned than the prairie dweller. Had the adaptability of soils to tillage been made the basis of clearing lands in the early days, there would be less talk of "thin" soils now, for on many farms lands were cleared which should never have been stripped of their first cover. Steep hillsides, rocky slopes, highlands with hardly a foot of soil between the surface and the underlying rock, have been denuded of their forest cover, and their subsequent tillage has been all but profitless to the farmer. With constant cropping they have become so impoverished that their cultivation has been abandoned. Yet, they have still enough fertility to support a vigorous tree growth. On many New England farms such thin lands have been planted to white pine with the most encouraging results. In many rocky, drift, eroded, and exhausted hill farms there is a depth of soil sufficient for the requirements of all varieties of trees, and the farmer within the forest area has thus a wide range of choice in the selection of trees. He may grow timber for railroad ties, for posts, for telegraph poles, for lumber, and for many other purposes, using the species that is best adapted to his need and to his locality.

In the Southern States the loblolly and short-leaf pines can be quite as readily grown as the white pine at the North. The loblolly seems to consider the abandoned fields its heritage, for throughout the lower Atlantic and Gulf States it quickly covers the old fields with its seedlings, which grow rapidly.

THE FARM NURSERY.

When such species as catalpa, box elder, black locust, green ash, white elm, and silver maple can be bought for less than $2 per thousand for strong one-year old plants, it would seem cheaper to purchase than to grow from seed. But with land, tools, and teams at hand, a forest-tree nursery can be cultivated at very little expense, and the farmer, by gathering seed of the native trees, and purchasing desirable seeds not to be had at home, can grow on a fraction of an acre seedlings enough for an extensive plantation.

Of the broad-leafed trees, the silver maples, elms, poplars, cottonwood, aspen, and willows ripen their seeds before midsummer. These should be planted as soon as ripe, care being taken not to cover the small seeds too deep. They will germinate in a few days, and by autumn will be of a size suitable for transplanting.

Of the species whose seeds ripen in autumn, those of the tulip, catalpa, honey locust, black locust, and Kentucky coffee tree should

be thrashed from their pods when gathered and kept over winter in a cool place where they will neither dry out nor mold. Birch seeds soon lose their vitality if permitted to dry, and they should be stored in close boxes or jars and kept over winter in a cool cellar. When the soil is moist in the fall, birch may be sown before the ground freezes, but in the dry soil of the plains the seeds should be kept over winter. They must be sown in beds shaded as for conifers, and covered very lightly. The seed usually ripens in August in the northern woods, and should be gathered at once, separated, and stored until planting time.

The sprouting of the seeds of other broad-leafed trees of the northern forest flora is hastened by subjecting them to the action of frost. This is accomplished either by fall planting or by mixing the seeds with sand and placing them in boxes on the north side of an outbuilding or other protection from the sun, whence they should be planted as soon as possible in the spring, or even, when the ground is sufficiently thawed out, in late winter. The nuts and acorns may be simply spread on a well-drained surface and protected from drying by a few inches of leaves held down by boards; but they are more subject to the depredations of rodents when thus disposed of. The seeds of fruit trees, such as cherry, mulberry, osage orange, wild crab apple, and hawthorn, should be separated from the pulp by maceration and washing before storing. Cherry and mulberry seeds ripen during the summer, and as the fruit is much relished by birds watchfulness is necessary to get them. They may be slightly dried after washing, and then mixed with sand. Some seeds, notably those of the hawthorns, are apt to lie over two or more years. Germination of such refractory seeds is hastened by soaking in water continuously for a week or more before planting.

When the soil is moist in the fall, the seeds of all trees which ripen after midsummer may be planted, and thus the labor of storing is saved. But spring planting is usually more satisfactory, because uniform conditions can be better maintained where the seeds have been properly stored. The soil is also usually in the best condition for receiving the seeds in the spring, and lighter covering is possible.

The forest-tree nursery should be placed in deep, moist, well-drained loam, and should be thoroughly cultivated. Hand weeding is important, for the tiny seedlings of many trees are very delicate and the more vigorous grasses will quickly choke them out if left unprotected. Where a large nursery is made, frequent use of the harrow-toothed cultivator is most desirable, for it keeps a dust blanket on the surface of the soil, which prevents excessive evaporation and insures the most perfect soil conditions obtainable through culture. Prompt attention is a requisite of successful nursery management.

Seedlings of box elder, silver maple, red maple, catalpa, black locust, cottonwood, willow, and mulberry are rampant growers the

first season, and their growth may be checked, to make transplanting less difficult, by sowing the seed thick in broad drills. Black wild cherry, the elm, the ash, honey locust, black walnut, tulip, crab apple, hackberry, linden, and coffee tree are of moderate growth and easily attain transplanting size the first year. The oaks and the nut trees generally, hard maple, beech, and hawthorn will usually be benefited by remaining two or three years in the nursery. The birches should be transplanted from the seed bed to the nursery row the second year, and set in permanent forest the third.

While the cone-bearing trees are more difficult to manage than the broad-leafed species, it will be found advantageous to the farmer to grow his own conifers. Not only are coniferous trees (pines, spruces, cedars, larches, etc.) more difficult to transplant, but they are disastrously affected by the drying of their roots, and in the operations of commercial nurseries—digging, storing, and packing—as well as in transit, there is more or less danger from this cause. It will frequently happen, too, that plants thus injured, unless the injury be very severe indeed, will appear in good condition when received, so that the purchaser accepting them will be disappointed in his stand whatever care he takes in planting the stock. Even should the cost of growing the cone-bearing trees be more than it would cost to purchase them, as will often be the case if the time of the grower be considered, the trees will prove cheaper in the end, because favorable weather can be chosen for transplanting them: they can be dug as needed, and absolutely protected from drying out during the brief interval between digging and planting.

Farmers living adjacent to the pineries can easily secure seed by gathering the cones just before they burst open and spreading them in a thin layer until sufficiently dry to open, when the seed will fall out. The same method is used in securing all seeds save the red cedar, the fruit of which is a gummy berry. The berries of the cedar should be soaked for several days in water, then rubbed together to remove as much of the gum as possible, when they may be planted or mixed in sand and kept frozen during winter. A bath in weak lye will hasten the cleaning process. The seeds of the remaining conifers are kept dry over winter. They can be purchased of leading seedsmen throughout the country, and, as a rule, come true to name, though difficulty regarding the Rocky Mountain species is sometimes experienced. As seeds lose their vitality to a considerable degree the second year and to a much greater degree thereafter, it is important to secure them fresh.

A well-drained, preferably sandy, soil should be chosen and the seed bed prepared as is usual for cold frames, so that as soon as the seed is planted the bed can be shaded. It should be open to the air on all sides, and the seed may be sown broadcast in the bed, or in drills a few inches apart. The seed should be covered but little, if any,

more than its own depth. Pine, spruce, and Douglas spruce seed usually germinates in eighteen to twenty days, red cedar in two to six months, and larch in twenty to thirty days. Shortly after the trees are up, or at any time during the first summer, a disease called "damping off" is liable to attack them. This is a fungous growth, and results in the decay of the tiny seedlings at the ground. It is often very destructive. The only remedy is to sow clean dry sand among the seedlings and withhold water for a few days. This is not always effective, but it will usually check the disease.

The shade for the seed bed is variously made. In the large nurseries it is usually a shed, roofed and sided with laths, but this would be too expensive for a farm nursery. Useful shades are made by laying brush across supports or by bunches of rushes or swamp grass similarly placed, but of course these are more difficult to keep in order. Where proper attention is paid to ventilation, an inexpensive shade can be made by tacking cheap sheeting to a frame to rest upon supports running along the side of the bed.

It may be advisable sometimes to purchase one or two year old seedlings from reliable growers. They should be planted, in shaded beds, about 3 inches apart, in rows 6 to 12 inches apart. It will be necessary to keep them shaded one to three years, according to their rate of growth. The oftener the cone-bearing trees are transplanted before being set permanently the better, as by this process the growth of fibrous roots close to the collar is encouraged. Especial care must be taken in handling conifers to prevent their roots from drying in the least, as whenever the roots dry it is almost impossible to make the trees live. The seedlings should be packed in damp moss at the nursery, and as soon as received the roots should be puddled in liquid mud and heeled in in a shaded place. The heeling in should be carefully done, the fine soil pressing close upon the roots, but not covering the tops. In a shaded place the trees may be left thus until the roots begin growth. In planting it is best to carry the trees in a bucket, with just enough water to cover the roots. They should be planted firmly and be well trampled, and a little loose soil dusted over the trampled surface to prevent baking. No tree should be set much deeper than it stood before, and this is specially important in transplanting conifers.

Conifers are ready for setting in plantations when from two to six years old. Larches can usually be set when two or three years old, the pines and cedars when from three to five years, and the spruces when from four to six years.

NOTES ON VARIETIES AND METHODS.

The Division of Forestry has frequently issued cultural notes on the leading economic species of American timber trees, and many of

the State horticultural societies, notably those of Kansas, Nebraska, Iowa, and Minnesota, have published manuals of forest-tree culture, so that detailed information for special regions is not lacking. While this is true in a general sense, little accurate information of the results of planting in waste places is available. In the West, where farm plantations have been attempted most extensively, the site chosen for the groves has been determined primarily by convenience, and it has seldom happened that the waste places have been selected. In the forest area little planting of any sort has been attempted on farms. Consequently the actual data of the results of waste plantings on farms are few.

Broadly speaking, the same rules which are practiced in forest planting in general are applicable to the waste plantings of farms; these include the adaptability of the species to the locality, attention to the light requirements of species, and to their rate of growth.

In ridge or high land planting it must be remembered that the soil is much less moist in such locations than in the valleys and lowlands, that the winds cause increased evaporation, and that droughts are especially severe. Trees requiring a generous supply of water will never succeed well in high, thin soils. This is particularly true of the plains, where not only a limited rainfall but excessive evaporation render the water supply much smaller than it is within the forest area. There can be no doubt that conifers will prove the most useful trees, as a class, for such locations. This is suggested by the natural tree covering of the Rocky Mountains, where the exposed highlands are clothed with pines, spruces, and firs to the tree line, while broad-leafed species are found only fringing the streams in the valleys. But the farmer who attempts to cover bare ground with a plantation of conifers will find it necessary to replant portions during several successive seasons before a good stand is secured. The reason for this is found principally in the difficulty of transplanting and in the light requirement of the conifers, which changes materially as the trees grow older. Almost all species of conifers are benefited by at least partial shade during the first few years of their existence. As they advance from the seedling to the sapling stage, those which are most light requiring, notably the larches and pines, are less tolerant of the shade of their neighbors, and reach up in an effort to spread their crowns in the full sunshine, but it is a well-known fact that the white pine endures the shade even of such densely foliaged species as the spruces during its infancy. Hence, it would seem best to begin the ridge plantation with broad-leafed trees, with the intention of introducing among them, in the course of four or five years, an equal number of conifers.

In the North the birches (*Betula lutea* and *B. lenta*) and aspen (*Populus tremuloides*) should prove useful for mixing with conifers, though we do not know of an experiment of this kind. They are

light-foliaged species, and while they are ordinarily found near streams they have succeeded well in the dry prairies of the eastern portion of the Dakotas. They are the natural neighbors and nurses of the pines and spruces in the Minnesota and Wisconsin woods. The first trees to appear on a great "burn" (a region where the forest has been killed by fire) are quaking aspen and the birches (*Betula lutea*, *B. papyrifera*, and *B. lenta*), and in their wake, if ever, the conifers appear.

Throughout the West a mixture of such broad-leafed species as box elder, silver maple, black wild cherry, bur oak, white elm, yellow birch, and green ash will be found useful in ridge planting, and south of the sand-hill region of Nebraska the Russian mulberry, catalpa, and black locust may be added. Of these, the species enduring the most shade during youth are named first. It will be noticed at once that several of these kinds are moisture-loving trees, but those here named have been grown in dry situations with a measure of success. The box elder and silver maple are short lived where grown in the ridge lands of the West, but during their first years they grow vigorously, and they will endure long enough to serve as nurses for conifers until the latter are established. Black wild cherry, while not extensively planted, has been grown successfully in various parts of Kansas, Colorado, and South Dakota—localities covering a sufficient area to warrant its extensive use. It has the further advantage of being a shade-enduring tree during youth, a point of much importance in the West, where comparatively few such succeed. It endures drought better than box elder or silver maple, being one of the hardiest species in this regard.

White elm, while a species of the greatest hardiness, is less vigorous in highlands than either wild cherry or bur oak, and is principally useful in plantings on such lands in giving variety. Bur oak has proven a most useful species in highland planting. It grows very slowly during the first few years, making but a few inches increase in height each year, and seemingly suppressed by its neighbors, but at the South Dakota Experiment Station, in a mixture of bur oak, elm, and box elder, the best bur oaks now equal the box elders in height, after eight years' growth. At the Kansas Station bur oaks planted on high limestone land, between rows of catalpa and black locust, have not made much height growth, being cut off every winter by jack rabbits, but vigorous shoots push out each spring, showing sufficient root development in spite of untoward conditions. The black walnut is not adapted to highland planting in the West.

In the use of such varieties as are named above, fully two-thirds of the trees should be of the dense-foliage kinds, and the remainder should be mixed with these so that each of them would be surrounded by dense shaders. They should be set not more than 4 by 4 feet apart, not only because they will most quickly shade the ground, and thus prevent weed growth, when close planted, but because a

dense plantation gives best results as a wind-break and as a snow catcher. During the first five years more or less damage is apt to result from the breaking of the trees by heavy snows, but this injury is seldom permanent, if the broken trees are pruned promptly in the spring. It is unnecessary to leave blank spaces for the introduction of conifers. By the time the broad-leafed trees shade the ground—in from three to five years—the conifers may be inserted where trees have failed, and may even be introduced between the rows. It is especially desirable that spruces and cedars be set thickly toward the margins of the plantation, as they form thus a protecting wind mantle for the more central trees.

Among the conifers which have been most largely tested in Western planting, the European larch, Scotch pine, white pine, Austrian pine, Norway spruce, red cedar, arbor vitæ, and white spruce are most common. Of these, the white pine, Norway spruce, and arbor vitæ are of little value west of the Missouri River, although some fine specimens of all these species can be found in the counties bordering that river. Among the Rocky Mountain conifers that would seem especially adapted to the West are the bull pine and Douglas spruce.

The European larch has been extensively planted in the Mississippi Valley, and it is especially useful in the planting of thin-soiled ridges. In a plantation on such land at Ridott, Ill., the larch is easily the best tree, with white pine and Norway spruce following in the order named. These species were originally planted in alternate rows with broad-leafed trees (walnut, ash, etc.), which they completely suppressed, very few of the latter being alive after twenty-five years. In 1895 the larches were thinned out, and made each from two to three fence posts 7 feet long, many of the butt posts being 10 inches in diameter. The remaining conifers stand from 30 to 40 feet high, and are from 3 to 8 inches in diameter. They include white pine, Scotch pine, Norway spruce, and arbor vitæ. The larch is sprawling in growth during the first few years, after which a leader is formed and the growth is very erect and straight. The species is deciduous, and the successive crops of leaves during the course of twenty years form a mulch so dense as to quite prevent weed growth. In Europe the larch is commonly used as a nurse for the pines, as the latter do not suffer in the slight shade of the larches, which grow more rapidly and are thinned out as the pines approach their principal height growth. This mixture has also been practiced at Elgin, Ill., with the most gratifying results.

In the drier parts of the West the white pine does not succeed, but throughout the prairie States it can be successfully grown in ridge lands. Beyond the Missouri the Austrian, Scotch, and bull pine will be found better adapted to the climate. So, too, the Norway spruce is not so useful in the dry region as are the Black Hills white spruce and the Douglas spruce.

Within the forest area—that is, in the States where the whole country was once covered with forest—different conditions prevail, and a much greater proportion of waste land is contained in the farms than is found in the prairies and plains. These lands consist largely of hillsides so badly washed as to be untillable and rough fields and pastures in which the impoverished soil will not produce a profitable crop. In the northern regions a large part of the hill country is made up of drift soils, of a characteristic clay loam, deep, moist, and well adapted to many kinds of tree growth. Farther south the hills are composed of granitic rock, which is still in process of disintegration. These soils are moist and in every way favorable to tree growth, as is indicated by the number of varieties and the great development of individuals standing in them.

The rapid-growing tulip tree, which furnishes the poplar timber of commerce, succeeds well in the moist hillside soils of the Alleghany region, and should prove a valuable species for mixing with the more dense-shading forms, such as maples and beech. The slow-growing oaks, especially such species as the red (*Quercus rubra*), black (*Q. velutina*), bur (*Q. macrocarpa*), white (*Q. alba*), and chestnut (*Q. prinus*), will also prove useful. Of these the black and red oaks are much more rapid growers than is usually believed, and all will be found worthy of a place in a mixed planting. The tulip poplar and the oaks are best introduced sparingly into farm mixtures, at the rate of from 24 to 50 per acre among other forms. They will thus be the ultimate trees, not interfering seriously with the development of the remaining forms, but reaching their full size when these have been mostly removed. If planted for its timber, the black walnut is best managed in this way also, though the walnut is essentially a tree of the valley as compared with hillside locations. The white hickory should succeed well on clay hillsides, and when well established can be treated profitably as coppice.

Of slow growth during youth, the sugar maple (*Acer saccharum*) is a most useful species in soils of this character, both on account of its forestal and its economic value. It endures the shade of other trees to an unusual degree, and thus forms a fine second to such rapid growers as black locust, tulip tree, etc. When these are removed, the maple develops more rapidly, and the foundation of a first-class sugar orchard may thus be secured. The beech is a neglected tree in America, though one of the most available forms known to the European forester. Like the sugar maple, it likes a deep, moist soil, and does not succeed in the prairies; but within the forest area it should prove one of the most useful shade-enduring species for hillside planting, especially on northern slopes.

In all waste planting on Eastern farms the use to be made of the wood crop is a more important consideration than in the West, where the incidental value of the plantation is of equal if not greater

importance than the resulting crop. In very few localities within the forest area is there a sufficient lack of fuel to make planting for this object of any importance. Broad-leafed trees, except as they yield material for stakes and posts, repairs, etc., are too slow in their development to make an attractive crop to the farmer, and hence the larches and pines would seem to be the most promising varieties to plant where a money return is looked for, unless the waste land is especially adapted to the growth of osiers or hickory coppice, or some special reason exists for the planting of hard woods.

When hillside fields are abandoned, they are soon covered with a growth of bushes, and seedling trees of many kinds appear. As a rule, the natural mixture thus spontaneously produced is not of much value. How can it be improved? Where there is a soil of considerable depth and sufficient moisture, even though the land be "worn out," the best oaks, chestnut, and hard maple can be introduced, the former by pressing the acorns and nuts an inch into the soil, covering with the foot, and the latter by sowing seed in hills. Such planting can be done without regard to the existing growth and without disturbing it, all these species taking a strong hold on the soil before top growth advances, and hence being comparatively indifferent to light in the early stage of growth.

A stand of conifers is more difficult to secure. Usually the surface of such waste lands is so covered with moss and other débris that seeds sown broadcast and left without further care fail to come in contact with the moist soil, and hence fail to germinate. Successful seeding has often been accomplished where the fields have been surrounded by mature trees and have been undisturbed by cultivation during a seed year, thus giving the pines an equal opportunity with less desirable species to sow their seed in the soil. Where the seed can be harrowed in, there is a reasonable prospect of a stand; but it will usually be found more profitable to plant the young trees, using such as have been one or two years in nursery rows after transplanting from the seed bed. In the spring, when the soil is moist, hillside fields and pastures may be planted thus to conifers with a dibble or spade, the distance apart depending upon the growth already established. On clean land the trees should stand close, not more than 4 by 4 feet. If there be a considerable soil cover of brush which can be used to nurse or protect the young plants, these may be set in at the rate of 680 to the acre (8 by 8 feet), or even less. Even in such cases thick planting is the more desirable, using a mixture of dense-shading (spruce) trees with light-needing species, such as the pines, or distributing the pines among larch seedlings, which grow very tall and slender and have proven good neighbors for the pines.

Where the white pine is native, a successful method of planting is to take up the young seedlings in the woods with the sod in which they grow, thus disturbing the root as little as possible. This is much

slower than where nursery plants are used. In clean fields men unaccustomed to the work can easily set 1,000 trees per day, while skilled workmen can almost double this number.

Close planting is less important in the Alleghany region, where there is an abundant moisture supply, than in the dry country west of the Mississippi River. In New England many successful planters set pines not closer than 10 by 10 feet (435 per acre). The objection to such wide spacing is that too great a growth of branches results on the lower part of the stem, producing knotty timber. Thinning should be sparingly done, the ideal stand during the first eighty years being one in which the trees are never so far apart that the branches will not touch each other when swayed by the wind, and during the first fifty years the trees should stand so close that the branches touch each other when still. This condition is best secured by slight and frequent thinnings (seven to ten years apart) during the period of most rapid growth. The increasing demand for box timber in the manufacturing districts of the East provides a market for pine and similar wood when 35 to 50 years old, thus permitting a short period of rotation in the forest management of waste lands in Eastern farms, and overcoming a principal objection to forest planting.

In all ridge planting, whether within or beyond the forest area, a leading purpose is the improvement of the soil, and this is best attained by close planting, which not only protects the surface soil from wind action, but also retains the leaves where they fall, thus enriching the soil by their decay.

The stand secured from any planting will of course depend upon the conditions of soil and climate at the time of planting and throughout the season, as well as the skill with which the planting is done. Climatic conditions play so large a part that there is always more or less danger of partial failure, especially with conifers. Within the forest region success is much more certain than in the plains, where, under favorable conditions at planting time, a stand of 60 per cent of the conifers set should be considered satisfactory. With no greater proportion living than this, replanting would be necessary the following spring, unless the blanks were so situated as to make filling in with cheaper deciduous forms possible. The aim of the planter should be to have the trees which he designs to stand until mature so distributed in his grove that they will each have the largest possible amount of space after the remaining trees have been cut out. Hence, when for any reason the conifers desired are expensive, if the planter intends to make his grove of coniferous trees, he may place them 8 by 8 feet, 12 by 12 feet, 16 by 16 feet (680, 302, 170 per acre), or even at wider intervals, and fill in the spaces to 4 by 4 feet or less with such trees as box elder, silver maple, Russian mulberry, catalpa, black locust, etc. Of these the first three named would fulfill only a temporary office and might be removed within ten or fifteen years, by

which time the others would have attained useful size. These could be thinned out from time to time, as necessary, leaving the land to the conifers alone within from thirty to fifty years of planting. Here again, if due regard to the light requirements of the several species has been observed in planting, the trees will be found in regular order, such light-demanding kinds as the pines and larches being surrounded by the shade-enduring spruces; or if only one coniferous form has been used, the subsequent thinning will be so managed as to give to each of the remaining trees the largest possible amount of light and room. It will be readily understood from these notes that the amount of pine, spruce, or larch that may be produced on an acre within a given time—as in fifty years—will depend quite as much upon the judgment which has attended the thinnings as upon favorable conditions of soil and climate. Fifty thousand feet, B. M., of white pine has been produced at 50 years of age from natural seeding with the aid of careful thinning. This must be considered an unusually large growth, and one-fourth as much would be good in ordinary practice.

PLANTING TO BIND SOILS.

Much of the waste planting of farms will be done to bind the soil of the hillsides which have been worn to gullies by long exposure and cropping. One of the best trees for this purpose is the black locust, which has a great root development and is one of the toughest woods. This tree is a native of the rocky hillsides of the Alleghany region, and succeeds well in all kinds of soils. It is a rapid grower, attaining a size suitable for vine stakes, intermediate posts, etc., in about ten years. It reproduces itself freely by sprouting, and spreads rapidly where planted pure. It is a thin-foliaged tree, and planted alone is not a soil improver, but it can be established where more desirable species in this regard can not gain a foothold, and these can be introduced later.

The locust is much subject to the attack of a very destructive borer, but this insect is less common than formerly, and its ravages are reduced to a minimum in mixed planting. Few broad-leafed species are of greater value than black locust for farm uses. It is the hardest and the most durable of our trees. Commercially, the timber furnishes the best wooden pins or treenails used in shipbuilding, and it is also used for wheel hubs.

A second important form of planting for the purpose of binding soils is that used in controlling the direction of streams by the planting of willows on their banks. East and West much fertile farm land is rendered comparatively waste by the windings of streams, which curve in and out, occupying wide stretches of bottom lands and making them useless except for pasturage. If simply a straight channel is cut for such streams, they soon wear the banks and are again uncontrolled. By planting willow cuttings in the sides of such cuts, a first

row near the water at its low stage and additional rows in the face and top of the cut, the roots soon bind the soil, holding it against the wearing action of high water. Either white willow or osiers can be used for such planting. Where fuel is scarce, the rapid-growing white willow will be found most useful. In such locations it attains a diameter at the butt of 5 to 8 inches in ten years, and as it sprouts readily from the stump it can be treated as coppice and will furnish a supply of small wood for many years. Where there is a market for them, osier willows can be profitably grown in such waste places. The species most commonly used is the red osier (*Salix purpurea* var. *Pyramidalis*). Cuttings from well-ripened wood, 12 inches long, are simply stuck in the washed banks. The osiers are more profitable where given high cultivation, and land too wet for corn but yet capable of cultivation is well adapted to them. The soil should be deeply plowed or spaded, and the cuttings set to the top bud in rows 4 or 5 feet apart, 1 foot in the row. The withes, or rods, should be cut close to the ground every year, including the first, in order to secure the strongest growth.

THE NUT TREES.

For highways, fence rows, and odd corners, those waste lands which often contain some of the most fertile soil in the farm, the nut trees are especially available. The black walnut has been largely used in the West as a fence-line tree, because of its rapid growth, excellent nuts, and ultimately valuable timber. It prefers a deep, rich soil, and is intolerant of drought, but in suitable localities it is a successful tree throughout the country east of the one hundredth meridian and south of the Minnesota line, though grown as far north as Minneapolis. The chestnut, like all nut trees, varies greatly in the quality of its fruit, and the farmer has abundant opportunity of selection in choosing nuts for planting. Although limited in its natural range of the country east of the Wabash and Kentucky rivers, it has been successfully grown in western Missouri (Kansas City) and central Iowa, and will probably succeed as far west as the Missouri River. Unlike the walnut, the chestnut succeeds well in highlands. Experiments in grafting Spanish and other improved chestnuts on the native stock have been entirely successful.

The pecan has attracted much attention in the Southwest during the past few years as a desirable nut tree, and as such deserves attention in this connection. The pecan is of even more limited natural range than the chestnut, its northern boundary being in southern Indiana and Illinois and its eastern line about central Kentucky. It is thus essentially a Southwestern form, and is worthy of the careful attention of farmers in that part of the country as a means of making waste places productive. It is successfully grown throughout the forest area south of New York. A great range of choice is possible in selecting nuts for planting, as they vary greatly even in the same grove.

The shagbark hickory is much less particular in its soil requirements than the pecan, although a closely related species. It occupies sandy ridges and clay hillsides as well as the richer lowlands, and is well worth consideration as well for timber as for its fruits. Its habits being understood, it should be a useful species for waste farm planting. In its natural state it grows in open groves with hazel or other undergrowth. While usually more or less mixed with other trees, it is often the dominant form over considerable areas. It is a light-demanding tree, and is difficult to transplant unless specially prepared by the cutting of the taproot a year previous to setting. The mocker nut, variously called Missouri nut, bull nut, king nut, etc., is more southern in its range than the shagbark, which is found from New England to southern Minnesota. The hickories can be profitably grown as coppice, the cuttings having an established value for hoop poles.

The nut trees are best grown by sowing the nuts where the trees are to stand. Along fences they can be grown in open hedge rows, and during their earlier years will fruit freely in such plantings. As they grow older those which bear inferior fruit can be cut out, giving necessary room for the remaining trees. If grown on highways, the nut trees will be benefited by being mixed with some low-growing, woody plant, such as sand cherry, coral berry, wild gooseberry, or some low-growing tree, like wild plum, ironwood, or dogwood. Such undergrowth will prevent weed growth and thus further the especial purpose of the plantation.

If the fruit rather than the timber is the principal crop desired, the nut trees should be encouraged to form large, open crowns, admitting light freely, for fruit is produced only under such conditions. Therefore, in the planting of odd corners, fence lines, and highways with nut trees, if other species are mixed in they must not be permitted to shade the nut trees, but must be lower growing, or very erect, in which case but few should be used. The nut trees may require some nursing during the first ten years, to induce them to form a trunk of proper height, especially in roadside planting, but when this is attained their crowns should have full sunlight. At the same time several species are peculiarly subject to sun scald, especially the hickories and white walnut, or butternut (the latter is excluded from this list on this account), and this suggests the advisability of mixing with them a low-growing tree which will shade their trunks during youth. In the North Central States the Russian mulberry should prove a useful tree for this purpose, as it is a rapid grower during youth and of only moderate height. Of the shrubs suggested for use as undergrowth none can gain a foothold until the crown cover has been raised considerably from the ground, after ten or twenty years, so that this is an after consideration, unless all be planted at the same time.

Among the trees of possible culture in waste places the especial

usefulness of several may be mentioned. The hardy catalpa is one of the few rapid-growing trees whose wood is very durable in contact with the soil, and it is therefore unexcelled as post timber. It does not succeed north of central Iowa nor west of the ninety-seventh meridian, but within its range it is one of the most rapid-growing trees, and will prove a useful timber on every farm for posts, stakes, and rails. The European larch, though not so durable in contact with the soil, can be grown over a wider range, and is an excellent post and rail timber. More trees of this species can be grown to large size on a given area than of any other, because of its erect habit. Thus, trees standing 4 by 4 feet can be grown to good rail size without thinning.

The white ash in the East and the green ash in the West should be included in farm planting on account of the usefulness of their timber, when properly seasoned, for machinery repairs. While of slower growth than the foregoing, they yet attain a useful size for many purposes within twenty-five years. Like the black locust, they should be scattered among other species to reduce the danger from borers. The white elm yields a tough timber that can be applied to many farm uses, and as it succeeds in most locations it should form a part of all plantations. The hickories, aside from their excellent nuts, are among the most useful of farm timbers, because of their toughness and elasticity. The black wild cherry is most useful incidentally in the farm plantation, as it produces a fruit much relished by birds, and has a high forestal value. The timber attains its peculiar value only with age, as is the case with the black walnut.

The wood of pines and spruces is of comparatively little value until the trees are mature, as it is neither so strong nor so durable as that of several species mentioned. The incidental value of these conifers is greater than that of broad-leafed trees, as their leaves are held through the winter, thus greatly increasing their usefulness as windbreaks. The well-known superiority of the lumber of mature trees needs no comment. The red cedar is one of the most durable timbers known in contact with the soil, and the arbor vitæ is only less valuble as a post timber.

The common cottonwood is one of the least useful trees for waste planting on the farm, because it succeeds well only in fresh or moist soils. In the far West it is a useful tree for planting in seepage spots, and it can be well grown in all moist soils. It is neither durable nor strong, so that its principal value is in its rapid growth, giving an early supply of fuel. Of the willows, the leading one is the common white willow, which is especially useful as a wind-break, but the willow also likes a moist soil, unfitting it for most waste planting.

THE ASPARAGUS BEETLES.

By F. H. CHITTENDEN,
Assistant Entomologist, U. S. Department of Agriculture.

GENERAL REMARKS.

Asparagus was introduced into this country with the early settlers from Europe, and is credited with having been cultivated here for two hundred years before being troubled with insects.

A number of species of native American insects have been observed to feed upon this plant, but none, so far as we know, have become sufficiently attached to it to cause serious injury. Few of our edible plants, in short, down to the time of the civil war have enjoyed such immunity from the ravages of insects. (Fig. 84.)

FIG. 84.—Spray of asparagus, with common asparagus beetle in its different stages; asparagus top at right, showing eggs and injury—natural size (original).

In the Old World two insects, called asparagus beetles, have been known as enemies of the asparagus since early times. In the year 1862 one of these insects, known to science as *Crioceris asparagi*, and which may be called the common asparagus beetle, was the occasion of considerable alarm on asparagus farms in Queens County, N. Y., where it threatened to destroy this, one of the most valuable crops grown on Long Island. Subsequent inquiry, brought about chiefly through the efforts of Dr. Asa Fitch, then official entomologist of the New York State Agricultural Society, developed the fact that the species had

begun its destructive work at Astoria, near New York City, in 1860, and it is now conceded that it was introduced in this locality about 1856.[1]

In 1881 another European importation was detected on asparagus near Baltimore, Md. This latter is *Crioceris duodecimpunctata*, commonly called the twelve-spotted asparagus beetle.

THE COMMON ASPARAGUS BEETLE.

(*Crioceris asparagi* Linn.)

From the seat of its introduction at Astoria, forty years ago, the asparagus beetle soon spread to the asparagus farms of Queens County, N. Y., and by 1862 it was reported to have occasioned the loss of over a third of the crops of certain localities, such loss being estimated at $50,000.

The injury inflicted by this insect is due to the work of both adults and larvæ upon the tender shoots, which they render unfit for market early in the season and later destroy by defoliation of the high-grown plants, and particularly seedlings, the roots of which are weakened by having their tops devoured. The larvæ are sometimes so abundant that the black, molasses-like fluid that they emit from their mouths soils the hands of those who are engaged in bunching the stalks for market, and again the eggs are laid upon the stalks in such numbers that these latter are rendered unsightly and even slippery by their presence. Larvæ, as well as beetles, attack the tenderest portions of the plants, but the latter gnaw with seemingly equal relish the epidermis, or rind, of the stems. The beetles are also accused of gnawing young shoots beneath the surface, causing them to become woody and crooked in growth.

FIG. 85.—*Crioceris asparagi*: *a*, dark form of beetle; *b*, light form—enlarged (original).

A correspondent of the Department, Mr. William H. Hunt, an extensive asparagus grower at Concord, one of the leading towns in the cultivation of this crop in Massachusetts, writes that it is in establishing new beds that the greatest trouble and expense are incurred. The plant must grow a year as seedling and two more in the beds before being cut for table use, and during these three years it is constantly exposed to the attacks of this insect. Careful growers protect their beds, but careless growers, after cultivating a bed for one or two years,

[1] The capture of this species was recorded early in the present century in Pennsylvania—presumably near Hanover—and again in the vicinity of Chicago and Rock Island, Ill., about ten years after the discovery on Long Island, but, as the insect died out in these localities, these were obviously independent importations, and can not be considered introductions as the word is used of plants and animals, since the species did not obtain a permanent foothold.

become discouraged and plow it up and plant something else. Mr. Hunt states that five such instances have occurred in his neighborhood.

The adult beetle is a most beautiful creature, slender and graceful in form, blue-black in color, with red thorax, and lemon-yellow and dark-blue elytra or wing covers, with reddish border. A common form of elytral ornamentation in the latitude of the District of Columbia is illustrated at fig. 86, *a*. Farther north the prevailing form is darker, the lighter coloring sometimes showing only as a reddish border and six small submarginal yellow spots. (See fig. 85, *a*.) An extreme light form not uncommon in the southern range of the insect is shown by the same figure, *b*, for comparison. Its length is a trifle less than one-fourth of an inch.

DISTRIBUTION, PRESENT AND FUTURE.

From the scene of its first colonization in Queens County, the insect migrated to the other truck-growing portions of Long Island, and may now be found at Cutchogue, toward the eastern end of the island. It soon reached southern Connecticut, and has now extended its range northward through that State and Massachusetts to the State line of New Hampshire. Southward, it has traveled through New Jersey, where it was first noticed in 1868, eastern Pennsylvania, Delaware, and Maryland to southern Virginia.

Its distribution by natural means has been mainly by the flight of the adult beetles. Undoubtedly, also, the beetles have been transported from place to place by water, both up and down stream by rising and falling tide, as the fact that it has not until recently deviated far from the immediate neighborhood of the seacoast and of large water courses near the coast bears abundant testimony.

Another reason for the present prevalence of this species in these localities is that asparagus was originally a maritime plant and has escaped from cultivation and grown most luxuriantly in the vicinity of large bodies of water. It is well known that it is usually upon wild plants that the insect first makes its appearance in new localities. There is evidence also that its dissemination may be effected by what Dr. Howard, who has made a special study of the distribution of this and other imported insect pests, has termed a "commercial jump," either by commerce in propagating roots, among which the insect may be present either as hibernating beetles or as pupæ, or by the accidental carriage of the beetles on railroad trains or boats.

Only by some such artificial means of distribution has it in later years found its way to northwestern New York, in four counties between Rome and Buffalo, and to Ohio, where it now occupies a similar territory of four counties between Cleveland and the Pennsylvania State line. During the past summer Dr. Howard traced its course along the Hudson River above Albany. Inquiry instituted by Mr. F. M. Webster concerning the Ohio occurrence disclosed the fact that the plants in one locality were brought from New York. Its presence in

eastern Massachusetts in like manner may be due to direct shipments of roots from infested localities to Boston and vicinity.

It is noticeable that its inland spread, except in the neighborhood of water, has been extremely limited. It is present now in what is known as the Upper Austral life zone, although in certain points in New England it has located in what is considered the Transition zone. Its course up the Hudson River lies within a rather narrow strip of Upper Austral, and its location in the vicinity of Mechanicsville, about twenty miles north of Albany, marks its present most northern location. In all probability it is destined in time to overspread the entire Upper Austral zone and to make its way to some extent into neighboring areas in which it may find conditions for its continuance.

Through inquiry conducted during the years 1895 and 1896 by Dr. Howard the distribution of this species in Massachusetts, though wide, is found to be local. In New Hampshire it has been recorded from Nashua and Portsmouth. The species is reported also from Barrington, R. I., and is well established in Connecticut. It is possible that in a few years it may be able to encroach slightly upon the bordering States of Vermont in the vicinity of the Connecticut River Valley and Maine, near the New Hampshire seaboard. It is generally distributed through New Jersey, Delaware, and Maryland, and in southeastern Pennsylvania near the Delaware River. It is still local in New York and Ohio, but we may expect within a few years to hear of its invading other portions of those States lying within the Upper Austral zone; also Canada, of which there is a strip of Upper Austral bordering the northern shore of Lake Erie, and later Indiana, Illinois, and Kentucky and farther west.

HABITS AND LIFE HISTORY.

The insect passes the winter in the beetle state under convenient shelter, such as piles of rubbish, sticks, or stones, or under the loose bark of trees and fence posts. Toward the end of April or early in May, according to locality, or at the season for cutting the asparagus for market, the beetles issue from their hibernating quarters and lay the eggs for the first brood.

The egg is very large in proportion to the beetle, being nearly a sixteenth of an inch in length, and of the elongate-oval form illustrated at fig. 86, *b*. It is nearly three times as long as wide and of a dark-brown color. The eggs are deposited endwise upon the stem or foliage and in early spring on the developing stalks, usually in rows of from two to six or seven.

In from three to eight days the eggs hatch, the young larvæ, commonly called "grubs" or "worms," presenting the appearance indicated in fig. 86, *c*. The head of the newly hatched larva is large, black, and bead-like, its body is gray, and its three pairs of legs black. It at once begins to feed, and is from ten days to a fortnight, according to Fitch and others, in attaining full growth. When full grown

it appears as in fig. 86, *d*. It is soft and fleshy, much wrinkled, and of a dark gray or olive color, sometimes light, but not infrequently very dark. The head is shining black, as are also the six legs. Each segment is provided with a pair of foot-like tubercles, which, with the anal proleg, assist it in crawling and in clinging to the plant. The mature larva enters the earth, and here, within a little rounded, dirt-covered cocoon which it forms, the pupa state is assumed. The pupa is yellowish in color, and its appearance is sufficiently shown by the illustration (fig. 86, *e*). In from five to eight or more days the adult beetle is produced, which in due time issues from the ground in search of food and for a suitable place for the continuance of the species.

THE LIFE CYCLE.

Of the duration of the life cycle, Fitch has remarked that it is about thirty days from the time the egg is laid until the insect grows to

FIG. 86.—*Crioceris asparagi*: *a*, beetle; *b*, egg; *c*, newly hatched larva; *d*, full-grown larva; *e*, pupa—all enlarged (original).

maturity and comes out in its perfect form, but that the time will be shorter in the hottest part of the season in July and August than in the cooler days of May and June. These periods are for Long Island, New York.

During a hot spell in midsummer the minimum period of ovulation and of the pupa stage was observed by the writer at this Department. Eggs that were laid on the 5th of August hatched on the 8th of that month, or in three days. A larva transformed to pupa on August 4 and to adult August 9, or in five days. Allowing ten days as the minimum credited period of the larval stage, a day or two for the larva to enter the ground and form its cocoon, and two or three days more for the beetle to mature and leave the earth, the insect is again ready to attack its food plant and to continue the reproduction of its kind in about three weeks from the time that the egg is laid.

This may fairly be taken to represent the minimum midsummer life-cycle period of the species in the District of Columbia and southward.

In the colder climate of New England and in spring and summer weather the development from egg to beetle will require from four to perhaps seven weeks. The hibernating beetles appear here as early as April, and beetles of a later brood have been observed in abundance in October as far north as northern Connecticut. In its northern range two and perhaps three broods are usually produced, and farther south there is a possibility of four or five generations each year.

NATURAL CHECKS.

For some reason writers on economic entomology have overlooked the fact that the common asparagus beetle has very efficient natural checks, in the shape of predaceous insects of many kinds, which prey upon its larvæ and assist very materially in preventing the undue increase of this and other injurious species.

Beyond the reported statement that in 1863 "a small, shining, black parasitic fly"[1] destroyed great numbers of asparagus beetle larvæ on Long Island, New York, no parasitic or predaceous insect enemies were known in this country until 1896.

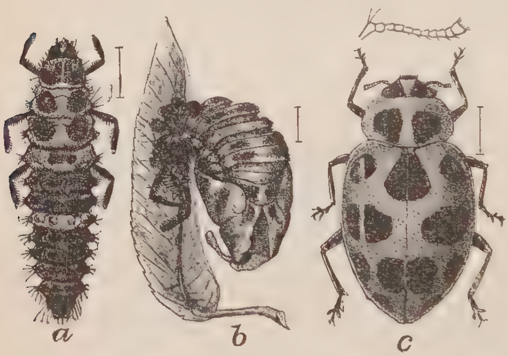

FIG. 87.—*Megilla maculata*: *a*, larva; *b*, empty pupal skin; *c*, beetle with enlarged antenna above—all enlarged (original).

The work of investigating predaceous enemies was continued for only a brief season the past summer and observations were confined to the country within a few miles of the city of Washington.

Of the many predatory insects observed on infested asparagus plants, a few are deserving of special mention. One of the most efficient of these is the spotted ladybird (*Megilla maculata* De G.). It was present in all the asparagus beds examined, its larvæ appearing to have no other occupation than that of devouring those of asparagus beetles. This insect in its several stages is represented in the illustration (fig. 87). The adult beetle is rose colored, with numerous black spots.

The spined soldier bug (*Podisus spinosus* Dall.) and the bordered soldier bug (*Stiretrus anchorago* Fab.) are also active destroyers of asparagus beetle larvæ, which they attack and kill by impaling them upon their long proboscides and sucking out their juices. The latter species is illustrated at fig. 88. Certain species of wasps and small dragon flies also prey upon the asparagus beetle grubs. Two of the

[1] Possibly *Myobia pumilla* Macq., which is known as a parasite of *Crioceris asparagi* in Europe.

most abundant of these are *Polistes pallipes* St. Farg. and *Agrion positum* Hagen. The method of procedure of these latter insects is to hover about the infested plants until a larva is descried, when it is pounced upon and carried away.

Asparagus beetles are very susceptible to sudden changes of temperature, and it has been noticed by one of our correspondents, Mr. C. W. Prescott, of Concord, Mass., that immense numbers of the hibernating beetles are killed in winter during severely cold spells following "open" weather, millions of their dead bodies being found under bark and in other hiding places.

The intense heat that prevailed at times during the summer of 1896, especially during the first two weeks of August, though conducive to the undue propagation of some species of insects, had the opposite effect upon certain species that feed in the larval condition freely exposed upon the plants. Upon the Department grounds and elsewhere in the vicinity this was particularly noticeable in the case

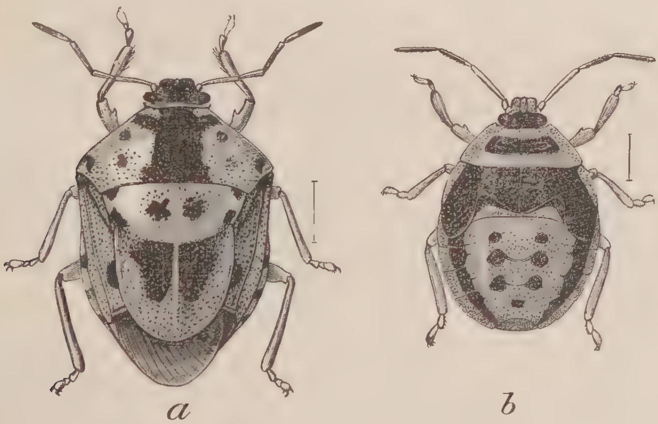

FIG. 88.—*Stiretrus anchorago*: *a*, adult bug; *b*, nymph—both enlarged five times (original).

of the larvæ of *Crioceris asparagi*. Their eggs also seemed to be dried up by the heat. What with their natural enemies and the heat, scarcely a beetle or larva of either species was to be found about Washington, D. C., after the last of August, though frequent search was made in the neighborhood.

REMEDIES.

Fortunately, the common asparagus beetle is not difficult of control, and under ordinary circumstances may be held in restraint by the simplest means.

Vincent Kollar, who wrote of this insect in 1837, said: "The only means of destruction is picking off and killing the beetles and larvæ." Fitch's only recommendation was the employment of domestic fowls for the purpose.

While hand picking is undoubtedly of some value in small beds,

and is still in use to some extent, it must of necessity give way to more approved methods for the vast myriads of the beetles that concentrate their forces upon the large areas that are devoted to this crop in the suburbs of our large cities. Chickens and ducks are efficient destroyers of asparagus beetles, and as they do no injury to the plant their services are still in requisition for this purpose at the present day.

An excellent practice that is in high favor among prominent asparagus growers is to cut down all plants, including seedlings and volunteer growth, in early spring, so as to force the parent beetles to deposit their eggs upon new shoots, which are then cut every few days before the eggs have time to hatch for the first new brood.

Other measures that have been employed with advantage consist in cutting down the seed stems after the crop has been harvested, and again once or twice during the cutting season, or in permitting a portion of the shoots to grow and serve as lures for the beetles. Here they may be killed with insecticides, or the plants, after they become covered with eggs, may be cut down and burned, and other shoots be allowed to grow up as decoys. The trap plants should be destroyed as often as once a week.

With concerted action on the part of growers in following out any of these last methods the insects should be held in check, at least in a region where the plant does not grow wild in too great profusion. Where this is not practicable, the insecticides must be brought into service. It is well in any case to employ the insecticides after the cutting season, since if the insects are destroyed at this time their numbers will be lessened for the next year.

One of the best remedies against the larvæ is fresh, air-slaked lime, dusted on the plants in the early morning while the dew is on. It quickly destroys all the grubs with which it comes in contact.

Pyrethrum is credited with being a useful remedy, and quite recently Professor Klein,[1] director of the experiment station at Karlsruhe, Baden, has reported that a mixture of soft soap, quassia decoction, and water (about equal parts of the first two to five of the last named) is effective against the larvæ, but these remedies will hardly commend themselves for extensive use until they have been thoroughly tested on a large scale.

The arsenites, applied dry in powder mixed with flour, as for potato beetles, answer equally well; they possess the advantage of destroying beetles as well as grubs, and are of value upon plants that are not being cut for food. Some of our correspondents use a mixture of paris green and air-slaked lime, or plaster, 2 pounds of the former to a barrel of the latter. It should be borne in mind that to produce satisfactory results the lime or arsenite must be applied at frequent intervals, or as often as the larvæ reappear on the beds.

A simple and inexpensive method of killing the larvæ in hot weather

[1] Berichte d. Grossh. Bad. Landw.-Bot. Versuchsanstalt z. Karlsruhe, 1896.

is to beat or brush them from the plants with a stick so that they will drop to the bare ground. The larvæ are delicate creatures, and, as they crawl very slowly, few are able to regain the shelter of the plants, but die when exposed to the heated earth.

THE TWELVE-SPOTTED ASPARAGUS BEETLE.

(*Crioceris duodecimpunctata* Linn.)

A much rarer, and consequently less injurious, species than the preceding, at the present time, is the twelve-spotted asparagus beetle. It is generally distributed in Europe, where it is apparently native, and, although common, is not especially destructive.

Like the commoner species, it lives exclusively on asparagus, and the chief damage it does is due to the depredations of the hibernated beetles in early spring upon the young and edible asparagus shoots. Later generations attack the foliage, living, for at least a considerable portion of the larval stage, within the ripening berries.

INTRODUCTION AND SPREAD IN THE UNITED STATES.

The presence of this insect in America, as has been stated, was first discovered in 1881, and in the vicinity of Baltimore, Md. Dr. Otto Lugger, to whom this discovery is due, informs the writer that this beetle was noticed in considerable numbers from the first, showing that it had probably been introduced several years earlier. At that time it occurred quite locally, having been found only at the mouth of the Furnace Branch of the Patapsco River at a point a few miles south of Baltimore. It was then to be seen only on volunteer asparagus growing on the salty margin of this river, although beds of cultivated asparagus were plentiful in the immediate vicinity. Two years later the late Dr. Riley, then Entomologist of the Department of Agriculture, remarked that it had recently proved even more troublesome than the common asparagus species.

Assuming Baltimore to have been the original center of distribution, the twelve-spotted asparagus beetle has been traced southward through Anne Arundel and Prince George counties to the District of Columbia, where it was detected five years from the time of its first discovery. In 1892 it was reported to have appeared in considerable numbers on asparagus stalks that had been cut down upon a farm in Carroll County, Md. The same year Dr. J. B. Smith, entomologist of the New Jersey Agricultural Experiment Station, announced its appearance in Gloucester County, in southern New Jersey, and in the following year it was found in Cumberland and Camden counties of the same State.

To have reached these points the insect, obviously, had traversed the intervening country, comprising Harford, Cecil, and Kent counties in Maryland, the northern half of Delaware, and Salem County, N. J. It was also found to have reached Virginia, near Washington.

In 1894 it had extended northward to Burlington County, N. J., and westward to Philadelphia County, in Pennsylvania. The same year it was detected in Queen Anne County, Md.

The past year (1896) it was found to have established itself in Charles County, Md., and to have penetrated as far south in Virginia as Westmoreland County.

In May, 1896, a serious invasion was reported in Prince George County, Md., where the beetles attacked the young shoots, gnawing off the heads as soon as they showed above ground, thus entirely unfitting the crop for marketable purposes. As in most other cases of the reported presence of this insect, it was accompanied by the common asparagus beetle, which was first to appear on the beds, but soon gave way to the twelve-spotted species. During that year a number of new localities were added, including Westmoreland County in Virginia, the southernmost locality at present known for the species.

In addition to the above, we have a brief record, that of Dr. J. A. Lintner, who mentioned the occurrence of this insect in asparagus beds in Monroe County, N. Y., in 1894. This is at a point near Rochester, in the northwestern part of the State, and not far from Lake Ontario. Its remoteness from other known localities of the insect leads naturally to the conclusion that this must have been an independent or at least an artificial introduction, therefore a second center for its further distribution. It seems hardly probable, however, that the species will spread from this point with the same degree of rapidity that it has done from Baltimore, as it has here reached the northernmost limit of the Upper Austral life zone, and its progress in following this life zone would be southwest, whereas from Baltimore it spread in all directions.

To the above must be added the finding of the species by Mr. M. H. Beckwith, at Millsboro, Del., in the northern portion of that State.

PRESENT AND PROBABLE FUTURE DISTRIBUTION.

From available data it is now fairly established that this species is at present distributed throughout the asparagus-growing country in the southern half of New Jersey, the whole of Delaware, nearly the entire State of Maryland, the District of Columbia, the southeastern portion of Pennsylvania bordering the State line of New Jersey, and northeastern Virginia in the vicinity of the western shore of the Potomac River.

At first its progress was slow, but within the past few years it has traveled more rapidly. The theory that water has played no small part in spreading the asparagus beetles is exemplified in the case of the present species, as it will be observed that it had spread to Washington, D. C., 35 miles southwest of Baltimore, within five years of its discovery, while its appearance was not noticed at any distance east or north of Baltimore until six years later.

Having a different starting point from *Crioceris asparagi*, this species has nevertheless followed somewhat closely the course of the latter,

particularly southward, along the coast line, rivers, and other water courses, and, like the latter also, it has been slow to spread inland. At its present rate of distribution it has at least as wide a range as the older species was known to have gained in the same number of years after its introduction. Although, as already stated, it is far less injurious than the latter in Europe, and not so abundant in this country, save in a few localities, it would be unsafe to predict its future destructiveness. That it will in time invade the territory now occupied by the common species in the North and West as it has in the South there can be no reasonable doubt; that it is capable of inflicting considerable injury has been proven, but it will be a matter of several years before it can be classed as more than a sporadically injurious species.

DESCRIPTION, LIFE HISTORY, AND HABITS.

The mature beetle in life rivals *asparagi* in beauty, but may be distinguished by its much broader elytra and its color. The ground color is orange red; each elytron is marked with six black dots, and the knees and a portion of the under surface of the thorax are also marked with black. (See fig. 89, *a*.) The beetle, as it occurs on the plant when in fruit, very closely resembles at a little distance the ripening asparagus berry.

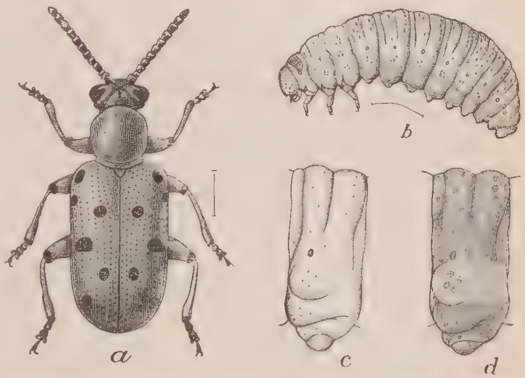

FIG. 89. *Crioceris 12-punctata*: *a*, beetle; *b*, larva; *c*, second abdominal segment of larva; *d*, same of *C. asparagi*—*a*, *b*, enlarged, *c*, *d*, more enlarged (original).

The common asparagus beetle, as is well known, dodges around a stem like a squirrel when disturbed, but the twelve-spotted form appears to trust to flight, taking wing more readily than the other. Both species make a loud creaking sound when handled, by what is called stridulation, produced in the present species by rubbing the tip of the abdomen against the elytra.

The full-grown larva is shown in the illustration at fig. 89, *b*. It measures, when extended, three-tenths of an inch (8 mm.), being of about the same proportions as the larva of the common species, but is readily separable by its ochraceous orange color. The ground color is light yellowish cream with an overlay of ochraceous orange which is most pronounced on the exterior portions of the abdominal segments. The head, with the exception of the mouth-parts, is also ochraceous, the thoracic plate is prominent, divided into two parts, and is of a dark-brown color. Enlarged figures of the second abdominal segment of both species are presented at fig. 89, *c* and *d*, for comparison.

The life history of the insect is as yet imperfectly understood. The egg has not been found and only a few of the young larvæ have been observed. One of the latter was upon the foliage of the plant; the others, in various stages of growth, occurred in the berries. It might be conjectured that the eggs are deposited, like those of the common species, on leaves and stems, and that the larvæ of at least the first generation feed upon the same portions of the plant, but further observation is necessary to establish this.

The adult beetles feed, like the common species, upon the leaves and epidermis of asparagus stems, and, in confinement at least, also upon the berry.

In Europe the species is stated to be double-brooded, the first generation appearing in April or May, the second in August or September. The larvæ of the later generations feed preferably upon the berries, in which they live singly, introducing themselves into the pulp. The infested fruit reddens prematurely, and the larvæ, when full grown, cut their way out and escape to the ground, which they enter to undergo further transformation. The pupa state is said to require two or three weeks for the first generation and the entire winter for the second. Be this as it may in Europe, it is more probable, from what we know of the common asparagus species and other imported leaf-beetles in this country, that there are here more than two broods annually, at least in the more southern range of the species, and that hibernation takes place in the adult condition.

REMEDIES.

Of the efficiency of the remedies indicated for the common asparagus beetle there is ample testimony; that all of these, with the possible exception of caustic lime and other measures that are directed solely against the larvæ on the growing plants, would prove of value against the new species scarcely admits of doubt, but the habit of the larva of the latter of living for at least a considerable portion of its existence within the berry places it for that period beyond the reach of natural enemies and insecticides.

The collection and destruction of the asparagus berries before ripening might be a solution of the problem, but it is questionable if recourse to this measure would be necessary, save in case of an exceptional abundance of the insect.

THE FEEDING VALUE OF CORN STOVER.

By J. B. LINDSEY, Ph. D.,
Massachusetts Hatch Experiment Station, Amherst, Mass.

Corn or maize stover may be defined as that part of the corn plant remaining after the matured ears have been removed. The name is meant to include the entire stalk, leaves, and husks.

In 1895 the farmers of the United States planted about eighty-two million acres of land with Indian corn, which would yield about ninety million tons of field-cured corn stover. Supposing this stover to have the average feeding value and to be properly cured and housed, it would feed all the milch cows, oxen, and other cattle in the whole country for, approximately, one-fourth to one-third of a year. It is therefore of the utmost importance that the farmer should have a thorough understanding of the composition, digestibility, and practical feeding value of this fodder stuff.

COMPOSITION OF CORN STOVER.

While, from causes to be mentioned hereafter, corn stover varies more or less in quality, the average of a large number of analyses shows it to contain its several constituents in the following proportions:

Composition of corn stover.

Constituent.	Whole stover, field cured.	Water-free substance.				
		Whole stover.	Leaves.	Stalks.	Husks.	Timothy hay, for comparison.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Water	40.1					
Ash	3.4	5.7	7.9	3.6	3.5	5.1
Fiber	19.7	33.0	30.6	34.8	32.2	33.5
Fat	1.1	1.7	1.9	1.6	1.4	2.9
Protein	3.8	6.4	8.6	5.9	5.0	6.8
Nitrogen-free extract	31.9	53.2	51.0	54.1	57.9	51.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

Corn stover varies very much in the amount of water it contains. When brought under cover with fairly good weather for curing, it will contain from 30 to 40 per cent of water. After it has remained under cover for two or three months, if it is loosely packed, considerable water will have dried out, reducing the percentage to 20, below which it rarely goes.

In order to compare the composition of one coarse fodder with another, it is customary to leave water out of the calculation, comparing the actual dry matter only. This has been done in the preceding table. For comparison, the average composition of timothy hay is also shown. It will be seen that there is a very close correspondence between the whole stover and its various parts, the only essential difference, aside from the ash, being that the leaves contain somewhat less fiber and more protein, and, other things being equal, they should be slightly more valuable as a source of nourishment. The whole stover shows a composition practically identical with that of timothy hay.

The fiber and nitrogen-free extract of a fodder are frequently classified together under the name of carbohydrates, performing the same functions in the process of nutrition, namely, the production of animal heat, energy, and fat. Corn stover, containing fully 86 per cent of such substances, may well be termed a carbonaceous or starchy feed.

DIGESTIBILITY OF CORN STOVER.

A feeding stuff is valuable as a source of nourishment only so far as its various parts can be digested and assimilated by the animal. A chemical analysis shows the total amounts of constituents making up the feeding stuff, but this alone does not show the ultimate value of the material as a source of food. For this, knowledge of the proportion of the constituents digested is necessary.[1] The following figures show the percentages of the different constituents which the average animal is able to digest from the whole stover and its several parts, and from timothy hay and oat straw for comparison:

Digestibility of corn stover, oat straw, and timothy hay.

Constituent.	Whole stover.	Leaves.	Stalks.	Husks.	Oat straw.	Timothy hay.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dry matter	62	65	67	72	----------	57
Fiber	67	78	74	80	54	52
Fat	52	56	80	33	33	60
Protein	52	35	21	30	30	48
Nitrogen-free extract	64	68	69	75	44	63

No direct tests have ever been made to compare the digestibility of stover from different varieties of corn and in different stages of maturity. Experiments, however, with the entire plant—stover and ears—indicate that the large, coarse varieties are rather less digestible than the small and medium kinds. The figures as presented in the above table show that the entire stover, as well as its several distinct parts, is exceedingly well digested. The protein of the several separate

[1] Farmers' Bulletin No. 22, U. S. Department of Agriculture.

parts shows a rather poor digestibility. This is always the case when feeds very rich in carbonaceous substances (nitrogen-free extract and fiber) are fed alone. When supplemented by nitrogenous feeding stuffs, the digestibility of the protein would undoubtedly be increased. The figures also show that the whole corn stover and its separate parts are rather more digestible than timothy hay, and decidedly more so than oat straw.

A calculation of the amounts of the several digestible ingredients in 1 ton of well-cured stover with 20 per cent of water and in 1 ton of timothy hay gives the following result:

Amounts of digestible ingredients in 1 ton of stover and 1 ton of timothy hay.

Constituent.	Corn stover.	Timothy hay.
	Pounds.	*Pounds.*
Fiber	353.7	296.1
Fat	13.5	33.1
Protein	53.1	55.4
Nitrogen-free extract	544.6	553.6
Total	964.9	938.2

Assuming that an acre of land planted to corn will yield, in addition to the ears, 2 tons of stover, and that an acre equally well cultivated will produce 2¼ tons of timothy hay, a simple calculation shows that the stover will contain about 1,930 pounds and the hay 2,111 pounds of digestible food ingredients. Taking into consideration the average weather conditions affecting both crops, as well as the loss suffered by the stover in the process of curing, it would probably be safe to assume that the stover from an acre of land will furnish on the average, approximately, as much digestible matter as the timothy hay from a similar area.

LOSSES OF CORN STOVER.

In many sections of the country the idea seems to prevail that the stover has comparatively little feeding value. In different localities very different methods of harvesting are followed. In some sections the corn is topped above the ear and the leaves below the ear stripped off, while the stalk below the ear is regarded as of little or no value and is allowed to go to waste. Again, many farmers leave the entire stover uncut in the field, and in the late autumn or winter turn the cattle in and let them eat what they will, the idea being that this is cheaper than harvesting it. That such methods are very wasteful must be clear to everyone. Reliable experiments teach that of the entire corn stover the portion above the ear (tops) contains 27 per cent of the total digestible matter, the blades below the ear, 13 per cent; the husks, 26 per cent, and the stalks below the ear, 34 per cent. By

leaving the stalks below the ear in the field, one-third of the entire feeding value of the stover is lost. Again, if the stover is not cut till very late, the leaves dry up and are blown away by the winds.

CONDITIONS AFFECTING THE VALUE OF STOVER.

The value of the stover varies to quite an extent, according to time of cutting, variety, and weather conditions during the curing process. Until the corn plant has tasseled out, practically all its energy is devoted to growth, that is, to completing its ultimate size. This being accomplished, the plant materials assimilated by the plant are used in developing the ear, and the products being formed faster than they can be thus utilized, the balance is stored largely in the stalk as reserve material.

From the silking stage until full maturity the dry matter or actual food material has been shown to increase 50 per cent, that is, to be one and one-half times as great in the latter stage as when silking. In the later stages of the ripening process the actual assimilation of plant food largely ceases, and the plant draws more or less upon its reserve supply of material to fully develop the ear. In other words, the ear develops at the expense of the stover. The stover from fully matured corn is therefore liable to be rather inferior in quality to that cut, for example, when the ear is in the dough stage. Nevertheless it is not advisable to harvest the corn till about one-half of the leaves are dry, if climatic conditions allow and it is desired to secure the largest total amount of digestible food material in both grain and stover.

In the second place, stover from different varieties of corn differs somewhat in nutritive value. The stover of the earlier and smaller varieties is, other things being equal, to be preferred to that of the large, coarse dents. The quality of stover is considerably affected by the condition of the weather during the curing period, as will be shown further on.

CARE OF CORN STOVER.

To preserve stover in the best condition for feeding, the plant should be cut close to the base when about half of the leaves are dry and placed in stooks, or shocks, with the tops tied together to shed the rain. After standing a while to cure, the ears are husked and the stover placed back again to complete the drying process. If the grain is ripe, the ears can be removed at the time of stooking and husked when convenient. When a husking machine is employed, the cured stover will of course be run through the machine and shredded and the corn husked at the same time. Should the weather be fairly dry during October, the stover will dry out well. Very wet weather will retard the drying and cause the stover to decompose more or less in the stook. If it is necessary to store it in such condition, it will mold still further, with a corresponding shrinkage in feeding value. The

stover should be housed, if possible, before stormy weather. Being bulky, it will require considerable room. Too close packing prevents the further evaporation of water. When it is not possible to house it, it can be quite well preserved in large conical stacks, as is frequently practiced in the Western States.

Observations extending over a series of years show that stover, even when due care is exercised in its preservation, generally loses from 15 to 25 per cent of its feeding value from the time it is cut until it is fed. This loss is to be attributed to mold, loss of leaves, exposure to bad weather, etc.

PRACTICAL FEEDING OF CORN STOVER.

The opinions of farmers on this point have differed widely. Some have claimed that stover possesses but little nutritive value, while many others consider it to have about one-half the feeding value of hay. Its true feeding value depends to a great extent upon its mechanical condition, the quantity fed daily, and its proper combination with other feeding stuffs. When stover is fed whole, the average animal eats the leaves, husks, and tops, and refuses the stalks. It is only necessary to observe the farmer's manure pile to know the value he places upon his stover. To show the increased consumption caused by cutting corn stover, the Wisconsin Experiment Station conducted three feeding experiments with four milch cows. The cows were fed a grain ration and in addition all they would eat of cut or uncut stover. The corn was cut into inch lengths in a feed cutter, which also shredded the coarse stalks. The first two experiments were conducted with Pride of the North stover, a medium dent variety, and the last with Stowell Evergreen, planted thickly. It was found that cutting saved 36 per cent of the fodder in the first, 31 per cent in the second, and 9 per cent in the third experiment. It is probably a conservative statement that farmers lose fully one-third of their stover by feeding it whole.

PREPARATION OF STOVER FOR FEEDING.

Machines are in use which husk the corn and shred the stover at the same time. Many have pronounced them economical, while some have questioned the advantages to be derived from them. Professor Nourse, of the Virginia Experiment Station, who has recently given one of these machines a practical trial, reports very satisfactory results.[1] He says the "fodder is either cut by knives or torn into small bits by the shredder heads. We value the machine particularly for the improved condition in which it leaves the fodder." Any machine that will thoroughly shred the fodder is preferable to one that simply cuts it. Fodder that is shredded immediately on being drawn from the field is often so moist as to mold when thrown in large piles, and proves worthless for feeding. The New Jersey Experiment Station has

[1] Virginia Experiment Station Bulletin No. 33.

reported serious trouble from this course. On the other hand, if the fodder is stored for a few months previous to shredding, the danger is largely, if not entirely, avoided. This involves considerable extra expense, however, which sometimes renders it of doubtful economy. The fact remains that stover can not be shredded in any large quantity when moist without great danger of its rapidly becoming unfit for feeding. Farmers having power cutters of their own can shred at one time sufficient for a week's use without danger of its spoiling.

DIFFERENT METHODS OF FEEDING CORN STOVER.

Corn stover should not be the only feed given the animals if profitable returns are to be expected from its use. After the corn plant has well ripened it is by no means as palatable as hay, and animals very frequently refuse to eat more than enough to satisfy their immediate hunger. Again, attention has been called to the fact that it is a carbonaceous feed—a heat producer rather than a flesh former—and hence of itself an improperly balanced ration. One would expect a small milk yield if stover was the exclusive feed of dairy cows, for reasonable quantities of digestible protein must be supplied when a large milk flow is desired. When growing animals are wintered on corn stover only, they will do very little more than maintain their weight, for growing stock also needs digestible protein to produce bone and muscle.

A considerable number of experiments have been made with milch cows, comparing cut corn stover as an exclusive coarse feed with an equal quantity of good hay, the grain rations being the same in both cases, and the entire ration being what is termed properly balanced. The corn stover rations have produced from three-fourths as much to, approximately, the same quantity of milk daily as the hay rations, the yield being influenced somewhat by the length of the feeding period and the quality of the corn stover. While such a method of feeding is decidedly superior to feeding the stover exclusively, it can, in the writer's judgment, be improved upon. When milch cows are fed on stover as the only coarse fodder, they eat it well for a short time. They soon begin to tire of it, however, and within a brief period will eat no more than two-thirds as much stover as hay. In the first place, the stover lacks the agreeable odor and flavor of the hay, and, second, the use of large quantities of cut stover tends to make the animals' mouths sore, causing them to eat less than otherwise. This difficulty is far less when the stover is shredded. The writer believes that one (and sometimes both) of the above conditions operate to prevent animals fed on stover as the only coarse fodder from giving fully as large milk yields for long periods as are obtained from a good quality of hay. The writer has noticed the same conditions in case of growing steers when fed on grain and corn stover. The animals rapidly

tired of the stover, even more quickly than did the cows, making very much smaller weekly gains in weight than when fed more palatable coarse fodder.

BEST METHODS OF FEEDING STOVER.

So far as mechanical condition is concerned, the best results will naturally be obtained with the shredded stover. A properly balanced ration for milch cows should consist of one-third grain mixture and two-thirds coarse fodder; for young stock, one-fourth to one-fifth grain mixture and the balance coarse fodder. The writer's experience has indicated that not over one-half of the coarse fodder or one-third of the total daily ration should consist of stover. Fed in such quantities, animals will, as a rule, consume it for a long time, and it will give nearly, if not quite, as good results as an equal quantity of good hay. In addition to the stover, coarse fodder should generally consist of some kind of hay or silage. The writer prefers to feed animals but twice daily, giving about one-half of the grain and coarse fodder at each feeding. If the stover is fed at the same time as the silage, the flavor of the latter will be imparted to the stover, causing it to be eaten clean. Some good feeders moisten the cut stover with water and sprinkle the grain over it, making what is termed "chopped feed." This also imparts flavor to the stover, and will frequently induce animals to eat more of it with correspondingly satisfactory results. Another method for those who are able to practice it is to put the cut stover into a large covered wooden box, moisten with water, and mix about 1 pound of bran to 4 or 5 pounds of stover, and then turn in steam. The steam softens the stover and imparts the flavor of the bran to the entire mass. Thus prepared, it will keep several days, and if convenient a little steam can be turned in each day. A slight fermentation increases its palatability.

The following rations containing corn stover are suggested for milch cows. The amounts stated are per head daily.

Rations containing corn stover.[1]

I.

3 pounds wheat bran.
3 pounds gluten feed.
2 pounds linseed meal.
9 pounds corn stover.
9 pounds hay.

II.

6 pounds wheat bran.
3 pounds gluten meal.
30 pounds silage.
8 pounds corn stover.

III.

3 pounds Atlas meal.[2]
3 pounds corn meal.
3 pounds wheat bran.
8 pounds corn stover.
10 pounds hay of peas and oats.

IV.

4 pounds dried brewer's grains.
2 pounds cotton-seed meal.
20–30 pounds stover-bran mash.
6 pounds hay.

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[1] In case of fattening animals, corn meal, oatmeal, or hominy meal should be substituted for a considerable portion of the nitrogenous grains.

[2] A dried distillery feed.

Rations containing corn stover—Continued.

V.

4 pounds wheat bran.	7 pounds cotton-seed feed.
2 pounds linseed meal.	15 pounds silage.
3 pounds corn meal.	7 pounds corn stover.

The above rations are not to be followed blindly, the judgment of a practical feeder being always necessary to the greatest success. The grain rations can be used with any of the coarse-fodder rations. Not quite so much grain need be given if 25 to 30 pounds of the stover-bran mash is fed; 6 or 7 pounds would then be sufficient.

FERTILIZING CONSTITUENTS OF CORN STOVER.

The manurial value of corn stover should by no means be lost sight of. Two tons of cured stover—a good yield per acre—will contain, in round numbers, about 32 pounds of nitrogen, 10 pounds of phosphoric acid, and 50 pounds of potash. These materials ought to be returned to the soil to keep up its fertility, and passing them through the animal is the cheapest and quickest process of rendering them available as sources of plant food.

CONCLUSIONS.

1. Both chemical analysis and digestion experiments show that corn stover contains fully as many pounds of actual food materials as equal quantities of the best grades of hay.
2. The blades, husks, and stalks are all valuable for food; hence the entire plant should be cut when the corn is ripe, carefully cured, and housed.
3. One-third to one-half of the stover is very often wasted by improper methods of treatment and feeding.
4. In order that it be eaten clean, corn stover should be cut fine or shredded before being fed.
5. Stover very frequently lacks in flavor and is a one-sided or carbonaceous feed; hence it should not be fed alone.
6. Only about one-half of the total coarse fodder of the ration should consist of stover. It should also be fed in combination with by-products rich in protein.
7. The palatability of stover can be improved by moistening with water and sprinkling with bran. Steaming very much improves the mixture.

AGRICULTURAL EDUCATION AND RESEARCH IN BELGIUM.

By A. C. True, Ph. D.,

Director of the Office of Experiment Stations, U. S. Department of Agriculture.

Belgium has one of the most complete systems of agricultural education and research in existence to-day. This has been largely developed during the past five or six years. The growth of population, the requirements of intensive farming, and the increasing pressure of foreign competition have profoundly affected the farmer of the Old World. Both people and Government were slow to realize the significance of the changes taking place in agricultural conditions, but now that they are awake to the necessities of the case, they are laboring strenuously to give the farmer information and training which will enable him to overcome the difficulties of his environment and to compete at least on equal terms of knowledge and skill with his rivals in other lands.

EUROPEAN VERSUS AMERICAN METHOD OF PROMOTING EDUCATION.

It is well that the people of the United States should realize what active efforts are being made in the continental countries of Europe to give the rising generation sound and thorough technical education in agriculture and other arts. Under the political system there prevailing the Government takes the initiative in such matters. When once aroused to the importance of such a thing as technical education in agriculture, it is very likely to proceed with great energy to establish and enforce a complete system as far as this is practicable. It does not have to wait to convince a majority of the people that this is the best thing to do. It looks for its support to the leaders of science and industry and recognizes its duty to bring the people to see that what it attempts in this line is really intended for their good.

In this country, on the other hand, broadly speaking, systems of public education and scientific effort depend on the will of the people expressed through their representatives in local and national legislatures or boards. While here and there private munificence or even advanced public spirit may organize institutions for general or special education, these are not likely to affect the people generally until they are themselves convinced that it will be a good thing to have such institutions for their children. In the long run our plan may produce the best results because our educational institutions are founded on the intelligent choice of the people and have their sympathetic support. It involves, however, a period of agitation, during

which the merits of any particular system must be submitted to more or less critical examination. Prejudice and conservatism must be broken down and the advantages of the new scheme be made sufficiently plain to induce the taxpayers to give their consent to the financial burden involved in carrying it out. This process may be a relatively long one and in the meantime other countries with a more paternal Government may temporarily get ahead of us in this particular. Something like this has happened with respect to education and research, especially in the arts and industries. Thirty or forty years ago our people had made such relatively rapid progress in establishing systems of free public instruction that they received the congratulations of mankind on this account. The belief that we had the best educational system in the world became firmly fixed in the public mind, and we have thus far remained in too great contentment with our lot in this matter. We have thus been blinded to a certain extent to the fact that while we have gone on strengthening and improving our educational system, European countries have made herculean efforts to outstrip each other in educating their people and have in many particulars elaborated more nearly perfect systems than our own. The limits and scope of this article will only permit the calling attention to the broad and fundamental facts which must be taken into account if we are to make a just comparison of European with American educational systems.

In approaching the study of Belgian institutions for education and research in agriculture it is well to bear in mind, first, that the rapid progress made in developing such institutions in that country in recent years has been largely due to the energy displayed by the Government in this work, and, second, that concentration by the Government on this problem has enabled it to perfect the system beyond what has been attempted in this country.

GENERAL CHARACTERISTICS OF BELGIAN AGRICULTURE.

Belgium, we should remember, is the most densely populated country in Europe. Within an area smaller than that of Massachusetts and Connecticut is crowded a population as large as that of the State of New York. Of the total area of 7,275,000 acres, less than 600,000 acres are waste land. The subdivision of estates has progressed so far that many of the so-called farms are mere garden patches of from 1 to 2 acres. As in other countries of Europe, the people live in villages, from which they go out to their daily toil on the farms. The smallness of the farms makes it necessary, in many cases, for the family to engage in other industries along with farming. The famous laces of Belgium are largely made by women and children in the time when they are not engaged in agriculture. Here, as elsewhere in Europe, women and girls perform a large amount of labor in the fields. Agricultural machinery is little used. The soil is thoroughly tilled by

hand. Every available foot of ground is worked, rotation is practiced to maintain fertility and to increase the number of crops grown on the same land in a given time, and weeds are carefully kept out. Under the pressure of foreign competition, staple crops of grain are being crowded out. Much attention is given to horticulture, truck farming, seed raising, and dairying. Flax culture is an important industry.

GENERAL ORGANIZATION OF AGRICULTURAL EDUCATION.

While some institutions for agricultural education and research had existed in Belgium for many years, it was not until 1884 that the Government seriously undertook the task of providing a thorough system of agricultural education. At that time a ministry of agriculture was created "which at once undertook to restore the prosperity of the country by organizing, for the instruction of the farmers in the advanced knowledge given by science, a system of education as complete and thorough as that afforded by any other nation." After a careful study of the systems of agricultural education existing in other countries as related to the conditions and needs of Belgian agriculture, two laws were enacted April 4, 1890, which took the place of all previous legislation on this subject and permitted the establishment of the complete system of education now in operation. This system provides for primary, secondary, and superior schools or courses of agriculture. Primary agricultural courses for adult farmers are conducted under the direction of the ministry of agriculture, while courses of a similar grade for teachers and children are supervised by the ministry of public instruction. The secondary and superior schools of agriculture, as well as other agencies for promoting agricultural education and research, are directed by the ministry of agriculture.

THE HIGHER INSTITUTIONS FOR EDUCATION AND RESEARCH.

Scientific and technical training in agriculture is supplied by the Agricultural Institute of Gembloux and the School of Veterinary Medicine of Cureghem, Brussels, which are supported by the Government, and also by the Agricultural Institute of the University of Louvain. This last-named institute is organized as a branch of the scientific faculty of the university and provides instruction of the regular university grade. It possesses no farm and does not attempt to give instruction in the practice of agriculture. It is expected, however, that the students will acquire practical knowledge of farm operations before they are given a degree, and the practical application of the principles and theories taught in the laboratory and lecture room is enforced by numerous and varied excursions to different localities.

The School of Veterinary Medicine of Cureghem, in the vicinity of Brussels, is an institution of high grade. To secure admission to the course which leads to a degree in veterinary medicine, the student must first obtain the same university diploma which is required for admission to courses in human medicine. Special facilities are provided for the study of bacteriology and opportunities for clinics and other practical exercises are afforded in connection with a slaughterhouse and cattle market.

The oldest and most important of the Belgian institutions for higher education in agriculture is the Agricultural Institute of Gembloux. This was founded in 1860 and occupies the buildings and farm of an ancient abbey. It is in the midst of a rich agricultural region and only about 25 miles south of the great city of Brussels. The institution is thoroughly organized with a large and competent staff of professors and other teachers, and possesses ample laboratory equipment and relatively large collections of natural-history specimens and other illustrative materials, as well as a good working library and reading room. A farm of about 160 acres with fields and gardens for experiment and demonstration serves for illustration and practice in agriculture, horticulture, and forestry, while neighboring sugar factories, distilleries, and breweries afford opportunities for the study of agricultural technology in lines deemed of great importance in European countries. The students lodge and board at the institution. The courses of instruction are given in the French language and require three years for their completion. Candidates for admission must be 17 years old and are required to pass oral and written examinations in the French language, arithmetic, algebra, geometry, trigonometry, general and Belgian history, geography, and elementary physics. The course of study in the institute includes algebra, geometry, trigonometry, surveying, mechanics, hydraulics, agricultural engineering, physics, meteorology, chemistry (inorganic, organic, and analytical), agricultural technology, botany (including physiology and pathology of plants), bacteriology, zoology, entomology, mineralogy, geology, agriculture, horticulture, forestry, zootechny (i. e., anatomy, physiology, hygiene, feeding, breeding, and improvement of domestic animals), agricultural and forestry law, constitutional law, agricultural bookkeeping, political economy, rural economy, and microscopic analysis (with special reference to adulterations).

Here, as elsewhere in the European institutions for higher education in agriculture, more and more stress is being laid on thorough scientific training. The student is expected to be familiar with farm practice before he comes to the institute or to acquire this familiarity during vacation or in some other way before passing his final examinations for a degree. Experience seems to have demonstrated that in such institutions the farm and garden can be best utilized for purposes of illustration or as an agricultural laboratory. Trained

brains, rather than simply skilled hands, are required for the performance of the higher services demanded by agricultural science and practice to-day. The institute at Gembloux is not regarded as a school for teaching the operations of the farm; it is rather the training place for the future leaders in agricultural progress in Belgium. While the candidates for a degree are required to pursue a set course and submit to rigid examinations, students who desire to pursue special courses are admitted on liberal terms without examination. This is in accordance with the policy generally pursued at the institutions for higher education in Europe. There are thousands of students attending lectures at the universities in different European countries who have no expectation of taking a degree. It is believed that this freedom of admission to higher courses, on the whole, contributes to raise the general level of intelligence in the community and gives very many persons an opportunity to secure useful knowledge on special subjects which they would otherwise be deprived of. Of course, a considerable number of these special students abuse their privileges. Idlers and profligates are found wherever young men congregate. Nevertheless, this feature of the European educational system deserves more consideration than it has hitherto received from the colleges and universities in this country. In too many of our institutions the college grade of instruction is kept too low, with a view to getting more students in the regular college classes. We need to bring the requirements for degrees to a greater uniformity, without excluding from our colleges those students who might profit from special or partial courses.

THE SECONDARY SCHOOLS.

Having provided, as we have seen, for thorough training in the higher lines of agricultural education and having thus secured a considerable number of men fitted to be investigators and teachers of agricultural science and practice, the Government of Belgium has devoted itself to the maintenance of schools and courses of agriculture of a distinctly lower grade than those previously mentioned.

Three of the secondary schools are regularly organized under the general laws governing agricultural education. The school at Huy is devoted entirely to agriculture, while those at Ghent and Vilvorde give instruction in both agriculture and horticulture. The school at Ghent is the oldest of these institutions, having been founded in 1855. It has extensive buildings and grounds, and is thoroughly equipped with facilities for theoretical and practical instruction. Candidates for admission must ordinarily be at least 16 years old, and pass an examination in the French or Flemish language, national history, geography, and arithmetic. They must also give satisfactory proof that they are physically able to regularly carry on the practical work required in connection with their studies. The regular course occupies

three years, and includes instruction in the French, Flemish, German, and English languages, arithmetic, bookkeeping, geometry, geography, botany, elementary physics and chemistry, drawing, agricultural engineering, animal physiology and production, and the theory and practice of agriculture and horticulture. Especial attention is given to floriculture, which is a very important industry in Ghent, as well as elsewhere in Belgium. The minister of agriculture may admit pupils who desire to pursue special courses. These students are not required to take an entrance examination, and they may be relieved of practical work. For students in the regular course tuition is free, and some financial assistance is given to especially meritorious students who need it. In schools of this grade the effort is made to train young men for the practical pursuit of agriculture or horticulture on a relatively large scale. It is expected that they will become managers of estates or foremen in horticultural establishments.

Secondary instruction in agriculture and horticulture is also provided for in a number of private schools which are organized with reference to instruction in these lines in return for small subsidies. "As these schools are of different kinds, the Government has arranged three different courses of instruction from which a choice can be made according to the requirements of the individual school. These courses resemble the typical courses of the State schools of practical agriculture, but as the system of indoor discipline in most private schools does not permit sufficient time to be given to the practice of agriculture, the Government contents itself with requiring appropriate theoretical instruction." It is, however, insisted that object teaching and laboratory practice shall be made prominent in the courses in agriculture in these schools. Twenty of these private schools of agriculture are now in operation in Belgium and are so located as to meet the needs of the different agricultural regions.

Provision is also made by the Government for short courses in agriculture in public and private secondary schools for general education. These courses consist of at least one lesson a week during the school year, which must be given in accordance with the plan laid down by the Government. Thirty schools in Belgium are at present giving such courses. This plan has the advantage of providing at least an outline of the theory and practice of agriculture at small expense to a considerable number of students who are at the same time acquiring an ordinary high-school education. Such a course awakens their interest in the more scientific and advanced ideas regarding agriculture and prepares them to read with intelligence the reports of agricultural investigations. It also tends to make them more contented with rural life. It is believed that some such plan might easily be adopted in the rural high schools in many places in the United States.

Quite recently the Government has perceived "that it is important

for the agricultural prosperity of the country to train competent farm women as well as farm men." This would seem to be especially true in European countries where women perform numerous duties on the farm which in the United States are usually performed by men. A school for the theoretical and practical instruction of young women in agriculture, including dairying, kitchen gardening, domestic economy, etc., has been established in each of the provinces of Belgium.

LECTURE COURSES FOR ADULT FARMERS.

To meet the needs of adult farmers who can not attend schools, numerous lecture courses on agricultural topics have been organized. Each year some 250 courses of 15 lectures each on questions of general interest to farmers are given in the different rural districts of Belgium by graduates of the higher agricultural schools or other persons who are thoroughly competent for this kind of work. In an article on agricultural education in Belgium published in 1893, M. De Vuyst, an officer of the Belgian Government whose duty it was to supervise these courses, thus writes regarding them:

> To secure practice in this exceedingly difficult kind of teaching, the persons to give these courses meet together twice a year in each district. At these meetings one of their number presents a typical lecture and the others discuss it. The best lessons in the different courses are printed and distributed. At these meetings the improvements which are most urgently needed by the farmers of the region are also studied.
>
> This method of organized courses of instruction in agriculture for adults is, we believe, peculiar to Belgium. The results which it has produced during four years are quite important. There are in the Kingdom about 2,500 rural communes. Within a few years no locality will have reason to complain that it has not enjoyed the advantages of this institution. The courses are attended each year by more than 10,000 farmers. The expense of conducting them amounts to only about $1 per hearer.

Besides these general courses in agriculture, special courses in orchard management, market gardening, dairying, animal husbandry, horseshoeing, apiculture, etc., are also given, and farmers' meetings of one or two days' duration, corresponding somewhat to our farmers' institutes, are held in different places under the supervision of Government officials. In each of the provinces there is a State agriculturist and an assistant agriculturist, whose business it is to hold farmers' meetings, deliver lectures, establish fields of demonstration in which the results of agricultural investigations may be shown on a practical scale, aid the agricultural societies in their work, collect agricultural statistics, and prepare reports on the agricultural condition of the country.

PRIMARY EDUCATION.

Thus far we have described the system of agricultural education organized under the ministry of agriculture, but the attempt is also being made in Belgium to teach the elements of agricultural theory

and practice in the primary schools. This work is under the direction of the minister of public instruction. To provide competent teachers for this purpose, the course of study in the normal schools has been reorganized so as to give regular attention to agriculture, and in order that the teachers already in the primary schools may be fitted to conduct the newly established courses of agriculture, special normal courses on this subject are provided during the vacation season. Agricultural instruction in the primary schools consists of two lessons a week which are given in accordance with the plan outlined by the Government. Financial or other encouragement is given to those teachers who excel in such instruction. It is clearly recognized that the success of this scheme depends almost wholly on the enthusiasm and efficiency of the teachers. Thus far there has been considerable difficulty in securing teachers having the right equipment of knowledge and teaching ability for this kind of work. For this reason the success of these primary courses of agricultural instruction has been quite varied in different places, and the matter can hardly be said to have passed beyond the experimental stage.

During the past summer the writer visited a primary school in Belgium which is fortunate in possessing a well-equipped teacher thoroughly interested in agricultural instruction. This school is located at a small village in one of the most populous districts of Belgium. At the time of the visit the teacher gave a lesson on the properties and uses of milk to a class of boys and girls about 12 years old. Samples of milk and cream, together with other illustrative material relating to the composition and uses of milk, were brought into the presence of the pupils, and by means of simple chemical experiments and skillful questioning, the teacher gave to the pupils a simple but clear explanation of such matters relating to the properties and uses of milk as they could reasonably be expected to understand at that early age. The summing up of the lesson by different members of the class showed that they had been well taught, and there is no doubt that from that time forth the horizon of their knowledge regarding milk will be considerably wider than if the lesson had not been given. The teacher of this class was a man, as it is not customary to employ women as teachers in the public schools in Belgium. He had evidently made good use of the very limited means at his disposal for providing illustrative material for his classes. The walls of the schoolroom were hung with charts, on many of which were pictures of agricultural implements, different varieties of plants, etc., which had been cut from advertising posters. Adjoining the school was a small garden in which a considerable number of different kinds of plants were grown and different methods of culture were tried for the information of the pupils. Close by were the rooms of the agricultural society of the village, which contained collections of seeds, grains, etc., as well as charts giving the composition of

fertilizers, results of experiments, and other things which would be of interest in connection with the discussions of the society, and which were doubtless available for use in the school. The teacher of the school acted as secretary of the society, aiding the farmers in the purchase of fertilizers and in other ways. Rooms were being fitted up for a cooperative dairy for the benefit of the villagers, which was to be supplied with the most improved appliances for the creamery business. It seems quite clear that children trained in a school under such circumstances would have a much broader outlook regarding agricultural affairs and be much more inclined to avail themselves of the results of advanced experience and experimentation in agriculture than their fathers had been.

AGRICULTURAL SOCIETIES.

The agricultural societies, to which reference has already been made, are also to a considerable extent under the direction of the Government. Numerous local societies are organized, and these are confederated in each province through the provincial society, whose affairs are managed by a representative assembly of delegates chosen by the local societies. These societies act as intermediaries between the Government and the farmers in disseminating information regarding agricultural progress and in helping to carry out any measures which may have been devised for improving the condition of the agricultural population. The societies receive subsidies from the Government, which enable them to conduct fairs, hold farmers' meetings, establish experimental fields, etc.

EXPERIMENT STATION AT GEMBLOUX.

Agricultural research is directly promoted in Belgium by the experiment station at Gembloux. This is well manned and equipped for research in the chemistry and physiology of plants and animals and in meteorology. Thorough and scientific work is done at this station. Analyses of foods and feeding stuffs, fertilizers, and other agricultural materials and the testing of seeds are carried on in laboratories organized for this purpose in seven different localities.

Reports of the investigations conducted at Gembloux and elsewhere in Belgium as well as information regarding the different institutions for agricultural education are given in a periodical bulletin published by the ministry of agriculture.

COMPARATIVE VIEW OF AGRICULTURAL EDUCATION IN THE UNITED STATES.

To gain a just idea of the comprehensiveness and thoroughness of the Belgian organization for agricultural education and research, the reader would do well to compare it with the system prevailing in his

own locality. In the United States we have thus far provided agricultural colleges, experiment stations, and farmers' institutes. For the general information of the farmer regarding the results of agricultural investigations and improved methods of agriculture we rely very largely on the publications of the experiment stations, the Department of Agriculture, State boards of agriculture, and the agricultural press. Regular primary instruction in agriculture is entirely lacking, and there is at present only one regularly organized secondary school of agriculture (in Minnesota), though the regular or short courses in agriculture in a number of our colleges are really if not nominally of the secondary grade. In view of the strenuous efforts which European countries are making to give regular instruction in agriculture to large numbers of their rural population, it is well that our farmers should seriously consider their needs in this direction and the best ways in which these needs may be supplied. It is certain that the colleges of agriculture need to be strengthened and developed in order that the leaders in agricultural education, research, and progress in this country may be as thoroughly trained as they are in the Old World. The grade of instruction in these colleges needs to be raised rather than lowered, and it is not to be expected that these institutions will send back to the farms any considerable body of practical farmers. Their graduates will for the most part be needed as teachers, investigators, editors, officials, and managers of those agricultural industries in which scientific attainments are indispensable to success. If any considerable number of the farmers of the coming generations are to have definite instruction in agriculture, it must be in schools and courses specially devised to meet the needs of those who for any reason are unable to take the long and expensive college course. This article will have served its purpose if it contributes in any measure to an intelligent examination of the problems involved in providing a suitable system of agricultural education in this country.

OLIVE CULTURE IN THE UNITED STATES.

By Newton B. Pierce,
Assistant, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

THE OLIVE REGION OF THE UNITED STATES.

The true North American olive belt—the region especially adapted to the growth and production of this fruit—includes a portion of Mexico proper, all of Lower California, and much of the State of California, exclusive of the mountain tops. There is another large section of the United States where the olive will grow, but which is not specially adapted to its extensive and successful cultivation. This region includes parts of Arizona, Texas, Louisiana, Mississippi, Alabama, Florida, Georgia, South Carolina, and probably also small portions of southwestern Utah and southwestern Nevada. The region particularly adapted to olive culture is, as already indicated, on the Pacific Slope, and this constitutes one of the largest and finest olive areas in the world.

The olive belt included within California is from 600 to 700 miles long and varies in width from 30 to 125 miles or more. If this belt were cut down to a width of 20 miles, which is greatly below its real average, and to a length of 500 miles, it would represent an area of 6,400,000 acres, or more than twice the area, according to official returns, of the land now set to olives in Spain, the most extensive olive-growing country in the world. This area adapted to olives within a single State embraces southern California and the region west of the Sierra Nevadas as far north as the upper portion of the Sacramento Valley and along the coast valleys and coast ranges to some distance north of San Francisco.

THRIFT AND LONGEVITY OF THE OLIVE IN CALIFORNIA.

The longevity of the olive in the Old World is proverbial. The olive tree also grows remarkably well on the Pacific Coast, and it is believed that in that part of the United States the conditions are well adapted to its continued wants. The experience of the Mission Fathers certainly leads to this conclusion. The olive was introduced at the San Diego Mission from Lower California soon after 1769, and between that date and 1823 it was planted in most of, if not all, the twenty-one missions of the coast. So far as known, the largest early plantings were made at San Diego and San Fernando, although some of the

oldest trees are to be found at Capistrano. It is stated that 500 trees were planted at San Fernando about the year 1800, and at present about 450 of them are in a fairly thrifty condition. Probably none of the California trees have reached a diameter of much more than 2 feet, a fact which emphasizes the great age of the monster olive trees of the Mediterranean region.

PRESENT ACREAGE.

The acreage of olives on the Pacific Coast can not be accurately given, but it runs well up among the thousands. Some idea may be had of the growth of this industry from the fact that in 1894 over 400,000 olive trees were sold for planting from the nurseries of Pomona, Cal., alone, while the shipments and orders for the first half of 1895 amounted to 500,000 trees. In June of the year named it was estimated that 600,000 olive trees would be planted in California in 1895. If this number of trees were set as close as 20 feet, they would then represent an increase of olive culture to the extent of over 9,000 acres in two years.

THE OUTLOOK.

Olive culture has ever been among the foremost branches of horticulture in the portions of the Old World suited in climate to the growth of the tree. Spain alone has an olive acreage nearly as great as the area of the State of Connecticut and more than twice the area of Delaware, although that country is but one-fifteenth the size of the United States.

Some idea of the possible monetary value of olive growing to the United States may be drawn from the extent and value of the industry in other countries. From the latest and most conservative and official data it is estimated that the value to the United States of a yield of olive oil equaling in amount the annual yield of Spain, if sold at prices brought by the French product, would be $80,000,000 per annum. So far as climate, soil, and ability to manufacture the products are concerned, there is nothing to prevent our attaining this magnificent result.

The amount of olive products that will eventually be consumed by the United States will be very large, as in most of its forms the olive gives a very healthful and nourishing food. The oil of the olive is the finest obtainable, both for table and for kitchen use, while as a pickle and food for daily consumption the olive excels all other plants, especially when the fruit is allowed to mature and fill with oil before being preserved. Americans are naturally fond of pickles of all kinds, and the taste for the ripe olive pickle when once acquired leads to its constant use when the supply and the price are within the reach of the consumer. Good evidence of this is seen in the fact that few olives are at present shipped from the olive-growing sections of the

Pacific Coast, as they are mostly consumed where produced. The Spanish experience also demonstrates this. The estimated annual yield of olive oil in Spain is 78,627,136 gallons. Of this large quantity it is said that only about 10,000,000 gallons are exported, the remainder being consumed at home by a population which is only one-third that of the United States. Extensive use is also made of olive oil in pharmacy, in the manufacture of soaps, and for preserving sardines. Such facts show why the olive and its products have been so highly appreciated for thousands of years in olive-growing countries.

NEEDS OF OUR OLIVE INDUSTRY.

A careful review of the olive industry of the United States will show that it can easily be placed in a condition to enable it to assume in a few years a prominent and even a foremost position among the horticultural interests of the country. The one great need to-day is legislative action which will prevent the sale within the United States of other oils under the name of olive oil. Place the industry upon this equitable and necessary footing, and the growers of the olive in this country will rapidly gain control of the American market and the industry will assume its rightful and leading position. This result must almost necessarily follow from the fact that the production of pure olive oil in Europe is scarcely sufficient to supply European demand. If the producers could not, as at present, sell us peanut oil and cotton-seed oil under the name of olive oil and charge for it olive-oil prices, American dealers would have to supply the demands of consumers with the pure American product, provided, of course, the law had universal application. If cotton-seed oil were desired by the people, it could then be had at its true value, being sold under its own name by the American firms producing it, whereas now it is shipped to Europe by these firms, reshipped to this country as the product of the olive, and foisted upon the American public as "pure olive oil." Many who pay for olive oil and suppose they are using it have perhaps never tasted the pure article. This statement, which may at first seem exaggerated, is undoubtedly true in very many cases, and should stimulate the consumer to procure the California product that he may be assured of its purity, the California laws being very strict in the matter of oil adulteration. To secure the best the brand of some well-known grower should be selected.

METHODS OF PROPAGATING THE OLIVE.

The olive is propagated in many ways. Its production from the pit is not yet common in the United States, though several growers in California have started large numbers of seedling trees. It is somewhat difficult to germinate olive pits, and the seedling plants do not come true to name. A seedling olive, like a seedling peach, is usually suitable only as a stock upon which to graft. As the finer varieties

of olives become more extensively grown it is probable that grafting them upon wild roots will be found advantageous and become more general. In Europe many of the finer varieties are so grown.

The habit of the olive to vary from the parent plant when grown from the seed is valuable and admits of the selection of desirable qualities. The great economic value of some of the seedlings produced in California, as those of the peach, almond, walnut, etc., shows that it is advisable to select and bring to fruitage those seedling olives which give the best prospects of value through the characters of the foliage and the habit of growth.

When it is desired to grow olive seedlings, the oil of the pits should first be removed by soaking them for a few hours in weak lye or some other weak alkaline solution. After passing through this preparatory treatment, the pits may be stratified in sand and afterwards planted, much in the same way as grape seed is treated by many growers.

A new and important method of propagating the olive, which has been considerably developed in California within the past decade, is rooting small cuttings in sand in a hothouse. This system was first tried, as the writer is informed, about 1884 at the Berkeley Experiment Station. Some varieties are more easily rooted than others. The time to plant the little cuttings in the hothouse is during the late autumn and winter. From three to eight months are required to root them, according to the prevailing conditions of temperature and moisture and the variety which is being rooted. A little bottom heat is required while rooting most varieties, but some of the more easily rooted ones may be started under glass without heat, or even in a cold frame or lath house. Well-matured twigs, of about the diameter of a match and about 3 inches long, are selected for this purpose. These are stuck into the sand about one-half their length and all leaves removed except the uppermost two.

Much care is necessary in the management of these cuttings. One propagator writes: "Nothing is better calculated to take the conceit out of a nurseryman than the result of his first attempt to root olive cuttings under glass." The rooted cuttings may be planted out in nursery rows during the spring, summer, or autumn. By this method well-rooted and vigorous trees are produced, some of which have yielded fruit four years from the time the little twigs were planted in the sand.

Among the more easily rooted varieties are Mission, Nevadillo, Blanco, Oblonga, Manzanillo, and Redding Picholine. The last-mentioned variety is rooted extensively in cold frames. In fact, millions of olive twigs are now rooted annually by this process, and so largely has it superseded other methods that probably three-fourths of all the olive trees propagated each year in the United States are now rooted by this system.

A third system of propagation is by means of stools (fig. 90). This system is best adapted to those varieties which most readily produce a large number of long and rapidly growing shoots when cut back. The stocks designed for this purpose are set in rows 4 by 8 feet, and are cut back so as to induce them to send up numerous shoots from the ground level. When these sprouts are sufficiently long, they are separated and one-half of them turned down each way toward the adjoining stools of the same row, where they are bent and pinned down into transverse trenches which have been previously dug on either side of the stool to receive them. Before being pinned in these trenches the under side of each of these shoots is so cut as to cause quite a portion of the shoot to spring away from the main attached part when the shoot is bent into the trench. It is from this downward-projecting portion that the roots usually have their origin. After the cut is made and the shoot is pinned into the trench, the end

FIG. 90.—Rooting the Mission olive by the stool system.

of the shoot is turned upward, and the trench is packed full of earth as soon as all the shoots on that side of the stool are properly cut and pinned down. This work may be done in the spring or summer, the shoots being left buried until each has formed a good and abundant root system of its own. Usually from ten to twenty plants are obtained from a stool every two years. The Mission, Redding Picholine, and wild olives are especially suited to this mode of propagation.

While most of the olive trees now sold to growers are rooted by one or the other of the preceding systems, there are numerous other methods of propagation, some of them very common and time-worn. One of these is to bury olive limbs in a horizontal position in moist soil at a depth of 4 to 6 inches, cutting away and planting the rooted sprouts which they will send up. Another way is to saw large olive limbs into sections about 2 feet long, split into two to four pieces, and plant these truncheons in the nursery or directly in the orchard. A

third way is to cut out and plant in the nursery the hemispherical, knot-like swellings which are commonly found about the base of olive trees, watering them from time to time. A fourth way is to gouge out suckers from the parent tree and plant in the nursery, where they will root, provided enough of the wood of the parent stock is retained to prevent too rapid drying out.

GRAFTING THE OLIVE.

The grafting of the olive is now being extensively undertaken in California. If desired, the olive may be grafted upon hardy roots when the stock has become an inch in diameter, or the limbs of old trees may be grafted over, much as one would graft over an old pear or apple tree. Crown grafting of the semiwild Redding Picholine nursery stock has been practiced for several years by Mr. Rock with the most uniform success. In this case the stocks, which are usually grafted, average about 1 inch in diameter at the ground and are set about 1 foot apart in the nursery rows, the rows themselves being about 3½ feet apart, or sufficiently far for convenient cultivation. About the middle of March the trees are sawed off as nearly even with the surface of the ground as possible. The earth is then drawn away from the trees until about 4 inches of the stock is exposed. The grafts are inserted as soon as possible after the removal of the tops. The cut for the insertion of the scion is made near one side of the stock, the knife being held at such an angle that the cut is deep near the operator and runs out before reaching the opposite side. The knife is also directed inward toward the center of the stock in such a way as to cut across the grain. In this way the splitting of the stock is avoided when the scion is forced tightly into place. The taper of the scion should be thick and long at one edge and thinner and shorter at the other. More wood should be cut from one side than from the other, so that the cut on one side will not enter the pith, but leave the wood on that side of the scion smooth and hard from one edge to the other. When thus cut, there is no danger of the scion splitting when forced tightly into the cleft. In setting the scion the thick edge of the taper should be outward, so that the wedge and cleft shall agree, and the pith side of the scion should be toward the center of the stock. The stock is then tightly wound with common cotton twine, in an open manner, there being from four to six turns made about it. All of the cut surfaces of the scion and stock should be carefully waxed and the earth should then be drawn back about the stocks so that the stock and scion are both nearly or quite covered.

The T-budding, or shield budding, of the olive may be practiced if desired in working over the trees.[1]

As regards the growth of olives worked on hardy roots, the writer has seen Uvaria olives thus grafted which were higher than a man's head after three years from the time of grafting.

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[1] For details, see Report California State Board of Horticulture, 1889.

BEST LOCATION FOR THE ORCHARD.

In the Mediterranean countries olives are grown under a great variety of cultural and soil conditions, from the barren tops of high hills to the bottoms of level and fertile valleys. It is hardly necessary to say that the olive, like other fruit trees, will grow most vigorously in a rich, deep, friable, and well-cultivated soil. The olive is greatly benefited by thorough cultivation and by manuring, although it will grow and produce in uncultivated soil and often without artificial fertilizing. The olive will make the largest growth in deep, loose valley soil, but it should not be set on wet land. Valley cultivation of the olive is already too widely practiced in California to require further comment. The subject of hillside culture is the topic here most deserving of attention.

CULTURE OF THE OLIVE ON DRY HILLSIDES.

There is in California an immense area of hillside situations where the soil is fertile and the climate suited to olive culture, but where the moisture is not sufficient to enable the owners to grow other crops.

The profitable use of these dry hillsides is a subject of great interest to a large number of California fruit growers. Ranges of these hills extend for 700 miles through the State from north to south, and at present they are almost barren of crops of any kind. Millions of acres of the most fertile soils in the most equable climate are awaiting the intelligence of the cultivator to make them of permanent value. Can these hillsides be used for olive culture? An examination of the conditions under which the olive is grown in parts of the Old World strongly indicates that they can.

The rainfall conditions at Syracuse, Sicily, are much like those of the California regions under consideration. This is shown by the fact that the Mediterranean coast a few miles north of Syracuse is lined with great piles of solar salt, made by the evaporation of sea water in shallow basins along the shore. To those acquainted with the slowness of solar evaporation this will demonstrate the total absence or at least the very limited quantity of rainfall during the summer months. Moreover, raisins are made in the valley of Syracuse and the lemon groves are irrigated as in California. These facts show that the summers of Syracuse are long and dry—in fact nearly or quite as dry as those of southern California. Observation has taught the writer that the olive thrives everywhere in this region without irrigation. In the southeastern part of Sicily, where no irrigation of the olive is practiced and where the climatic or rainfall conditions are very similar to those prevailing in the drier portions of California, this tree grows to an enormous size and is perfectly healthy even to the very top of dry and otherwise barren hills.

The conditions in the vicinity of Naples, Italy, are a little different. During the summer there is usually a light shower or sprinkle about once a month. Irrigation is practiced for garden truck and citrus fruits, but not for other trees or vines. An account of the system of growing the olive on the steep and high hillsides back of Naples is here introduced as likely to be of value to Californians. The hills are too steep and rocky to admit of being cultivated, but nevertheless they have maintained thrifty olive groves for ages. The olive groves now covering these hills are not the original growth, the old, or original, trees having been cut back and the present trees grown from the margins or sapwood of the large stumps. The stumps of the original trees that covered these hills are from 2 to 5 feet in diameter. The surface of these hillsides is so prepared as to retain all the rainfall of the year and cause it to settle into the earth at the roots of the trees. To accomplish this the trees on the hills are planted at the apex of V-shaped excavations in the earth surface, the earth taken from the excavation being thrown into two ridges, which extend upward and outward from the tree. The tree is usually planted just below the V-like ridge of earth, so that when the excavation is filled by the rains of winter or spring the water will not stand about the trunk of the tree, but will gradually settle into the earth underneath it. The following diagram illustrates this method of culture, the V showing the ridge of earth and the dot indicating the position of the tree:

V V V V V V V V V V V V
. . . .

V V V V V V V V V V V
. . . .

It will be seen that in case of a heavy winter rain the excavations of one row of trees extending horizontally around the hillside must be filled with water before any can escape to the excavations for the trees in the row below, and so on to the bottom of the hill. Hence, if the excavations are of sufficient capacity the entire precipitation of any rain storm may be forced to settle into the hillside and as near the base of the tree as desired. It is to be hoped that a fair trial of this system of olive culture will be made upon the drier and steeper hillsides of the Coast Range of California, as it appears to be very successful in Italy on hillsides too steep for cultivation. (Pl. VI.)

In this connection it may also be well to call attention to the fact that throughout southern Europe it is generally held that the quality of oil produced from hillside groves is superior to that produced from groves in valleys.

To further strengthen the claim that the olive may be grown with success upon the driest California hillsides, the writer calls especial attention to the olive groves of Mr. Cooper, at Santa Barbara. Here the olive is now grown with marked success upon hills consisting of all kinds of soil and at all inclinations, and without any irrigation

HILLSIDE OLIVE CULTURE NEAR NAPLES, ITALY.

whatever. One of these groves, on a black adobe hillside, is 20 years old, has always produced well, and has never been irrigated.

DISTANCE AT WHICH TREES SHOULD BE PLANTED.

Full-grown olive trees often have an expanse of top from 50 to 100 feet, and must therefore have an abundance of room. The distance at which olive trees should be set from each other is a relative matter, depending on whether the grower is planting for ten, twenty, fifty, one hundred, or two hundred or more years of growth. If soil conditions are favorable, and time enough is allowed, the trees should be set 100 feet apart. The first ten years they may stand 20 feet apart, the second ten it would be better if they were 30 feet apart, and for the third ten a greater distance may be necessary. Like most fruit trees, olives will be of better form if set at a considerable distance apart, and will also make a better and more rapid growth, because the root system is not crowded.

Observations of closely and widely set orchards and vineyards, and a knowledge of the necessity of the olive receiving a stated number of heat units to mature its fruit, seem to indicate that it is better to set the trees at first 30 by 30 feet, provided it is not intended to remove some of them as soon as the growth of the orchard may require. When the trees are set close at the start, there is danger that they will not be thinned out until crowding has stunted them or injured their habit of growth. Considering, therefore, the requirements of the olive in the way of sunlight, air, root room, and cultivation, the need of spraying, the desirability of growing the tree in an open, spreading form, the fact that most fruit occurs on the lower limbs where most shade is encountered, and finally the convenience of picking when the tree is pruned to spread, it is thought best to recommend that 30 feet be allowed between the trees from the start. Planting the small olive trees a considerable distance apart does not preclude the profitable use of the land. While the trees are small it is a commendable practice to grow among them annual crops, such as corn, beans, potatoes, and vegetables of all kinds. In this connection we may cite the oft-quoted Italian saying, "It is well to wed the olive to the vine."

PLANTING.

The olive tree may be transplanted at any age until the tree is 6 inches or more in diameter. Trees from 10 to 20 years old may safely be set in orchards. The younger the tree the more care it requires. One-year-old trees are apt to be soft and sappy and the loss in transplanting from the nursery to the orchard is much greater than if the trees were older. The writer, from his observation, would recommend 3-year-old trees, as these are usually better supplied with fibrous roots and their roots and stems are hardened. The olive is a

rather difficult tree to transplant, and until it gets started should be given the same careful attention as the orange tree. After starting, there is no fruit tree which will stand so much abuse.

Before planting, the ground should be thoroughly plowed to a depth of, say, 12 inches, and all clods should be mashed. The excavations for the trees should be sufficiently large for the roots, which must be given a downward trend. The width and depth of these excavations should be not less than 18 to 24 inches. The root system of trees 2 to 3 years old should be well preserved and as complete as possible when transplanted. Broken or injured parts may be cut away with a knife. After digging the trees, the roots should be kept wet and covered with earth and the transplanting should be done as quickly as possible. As soon as the trees are planted, they should be thoroughly irrigated. If it does not rain, this should be repeated in about a week, then in two weeks, and again in a month. When the trees start they should receive about the same amount of water as a deciduous orchard. The soil should be kept pulverized to retain moisture. On dry land the trees should be given about two pailfuls each of water when planted and the same amount three or four times during the first summer.

The planting of trees for an orchard should take place early in the winter, or as soon as possible after the first heavy winter rains, so that the trees may get the benefit of all the precipitation and thus be as well prepared as possible to stand the heat of summer. January is probably the best month for planting olives, although they are also planted in February and March. The tree should be as nearly dormant as possible when transplanted.

PRUNING.

Olive pruning depends so largely upon variety, exposure, climate, and other local conditions that only some of the more general principles may be properly considered in this brief article.

After the nursery tree is set in the orchard it should be staked, but should not be pruned to any extent until it has established a good root system. An abundance of foliage is required to feed the roots and make the tree stocky. Close pruning of a tree in this stage of growth checks the development of the root system by cutting off its food supply, and the reduced growth of roots reacts upon the growth of the top. After the trees have reached a suitable height they should be headed back so as to establish the height of the trunks. In California the consensus of opinion appears to be in favor of low-headed trees (those measuring only 24 to 36 inches from the main forks to the ground). The number of branches left for main limbs may vary from four to six. All suckers and shoots below the forks should be removed as soon as the foliage of the main limbs is sufficient to protect the trunk from the sun. The main limbs are now allowed to reach a length of 2 feet or a little more, at which length the end of the branch is pruned off,

and likewise the ends of such terminal branches as project downward from these, one or two end branches being left to grow upward and outward. These secondary branches are in turn shortened back by having their leaders pruned as soon as they are 18 to 24 inches long. At the ends of these secondary branches are now preserved two lateral twigs, known as tertiary branches. These should be twigs which will grow upward and laterally. By the time they are well grown the form of the young tree is established, and further pruning for form may be done in a general manner to obtain the following results: (1) Maintenance of a comparatively open center to the tree; (2) exposure to the sun and air of as large a number as possible of last year's branches around the circumference of the tree; (3) removal of all ground suckers and water sprouts; (4) preservation of outward-growing and drooping basal and lateral fruit branches; (5) heading back of upward-growing limbs, which consume much, but produce little; and, (6) the removal of all diseased or injured wood. In pruning for form the rules governing pruning for fruit should be kept in mind (fig. 91).

Fig. 91.—Young Mission olive, showing method of pruning.

The annual pruning for fruit requires different methods from those already described. The bearing wood of the olive, except in the case of a few varieties, is that of the preceding year, that is, the growth of one summer blooms and bears fruit the following summer. This fact determines what branches should be preserved for fruit bearing. While the growth of last year is bearing fruit this year, it will also send out new lateral and terminal shoots which will bear next summer, but the oftener a branch has fruited the less will be the new growth and consequently the smaller the yield of the next year. Hence, by pruning away each winter a portion of the fruiting branches which have produced crops for two or three years, new fruiting branches will be forced from the old wood. This new growth is induced with greater ease in the olive than in the peach, the latter having wood which bears fruit in much the same manner. The location of branches to be preserved for fruit bearing should be low, as the lower branches are more apt to produce than the upper ones, and besides the fruit is more easily gathered.

Unpruned or imperfectly pruned olive trees have a tendency to fruit but once in two years. This habit may, however, be greatly modified, as already indicated, by the judicious annual removal of those branches which have already produced two crops. Some varieties are more readily induced to bear regularly by this system of pruning than others.

POLLINATION.

This subject was called into prominence by a bulletin on pear pollination by Mr. Merton B. Waite, of the Division of Vegetable Physiology and Pathology. Mr. Calkins, of Pomona, has made a start in these matters, and Mr. Mills, of the Pomona branch of the California Experiment Station, has also made some interesting and valuable experiments. Mr. Mills's experiments have shown in a surprising manner the need for the cross pollination of some of our olives and the fact that other varieties are perfectly self-fertile. The method adopted by Mr. Mills was that of bagging branches of bearing age for half their length before the buds opened in the spring. As yet this work upon the olive has not been sufficiently extended nor sufficiently thorough to warrant special conclusions, but it has gone far enough to show that it is important, for it is very necessary that the grower should know which varieties require cross pollination and which will set fruit with their own pollen (fig. 92).

FIG. 92.—Olive branches in fruit, showing a self-sterile and a self fertile variety (branches bagged up to the horizontal line).

CHARACTER OF THE FRUIT.

A few words on this subject may be of interest to those who have never seen the olive growing and know it only in the pickled state. As in the case of the peach, the olive is either clingstone or freestone. The ripe fruit is neither green nor yellow, but has a deeply colored skin—dark red or purple, reddish brown, purplish brown, light brown, deep brown, purplish, bluish, or reddish black, or jet black, with or without bloom. The fruit, even when ripe, is decidedly bitter, and

for pickling is put through a special process to remove this undesirable taste. It should be stated, however, that a few varieties of olives are known that bear sweet fruits, which, when ripe, may be eaten fresh from the tree, and when dried are also very good. Of the sweet varieties known to the writer, the best is the Piru Sweet No. 1. Piru Sweet No. 2 also bears a sweet fruit, and in these two imported varieties, of unknown origin, California has acquired two most valuable additions to the olive varieties now on the coast.

As is well known, olives vary greatly in size. The smallest are not as large as Malaga grapes, while the finer varieties of olives for pickling almost rival the size of our larger plums. The Sevillano, or "Olive of the Queen," as grown in the vicinity of Seville, Spain, frequently reaches a length of $1\frac{3}{5}$ inches and a breadth of $1\frac{1}{5}$ inches, while in California the same variety reaches even larger dimensions. In this connection it may be said that many varieties of olives bear larger fruits when planted in our virgin soils than they do when grown in the Old World.

The oil content of the olive also varies greatly, both in quality and quantity, in different varieties, and sometimes also in the same variety under different soil conditions or other influences. For pickling, the olive is usually plucked while green; for oil, it is allowed to hang on the tree until it is nearly ripe, which in California, for most varieties, is usually not until December or January. The olive tree begins to bear fruit when it is four, five, or six years old.

SELECTION OF VARIETIES FOR PLANTING.

In spite of the double dealing of some of the agents in foreign countries, who have been relied on to supply certain of the more valuable olives, and who in several notable cases have failed to fulfill their engagements, the numerous importations from many localities have now brought into our olive belt most of the more valuable varieties of olives of the Old World. This is encouraging, and assures us that the pick of the fruits of the world may be had by proper and persistent effort. The fruits of about eighty varieties of olives have been examined and photographed by the writer in California, and still other varieties are growing there which have not yet fruited, or at least not generally enough to enable one to judge of their quality.

In selecting olive varieties growers usually have two things in view—oil and pickles. Among the main considerations to be taken into account when selecting varieties for oil are quality and quantity of oil produced, prolificness, regularity of bearing,[1] early maturity of fruit if growing in a region where there is danger from frost, maturing of the fruit at different dates if growing in a region where frost is not feared, even ripening of the fruit upon the tree, and hardiness of the tree against cold and drought. When selecting varieties

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[1] See remarks on pruning for fruit, p. 381.

for pickling, the features for consideration, among others, are size of fruit, firmness of flesh when nearing maturity, form of fruit, uniformity in size and shape, even ripening of fruit upon the tree, prolificness, regularity in bearing, thickness of the skin and the quality of the fruit when pickled, and hardiness of the tree with respect to cold and drought.

Before selecting varieties for planting it would be well for the planter to consult a number of successful olive growers with special reference to the success of given varieties on the kind of land which he intends to plant and in the region which he has selected. In addition to these suggestions a few words may be said on particular varieties.

The following varieties of olives are believed to be among the best for oil, the names being those under which they were received by the writer or under which they are generally known in California, but

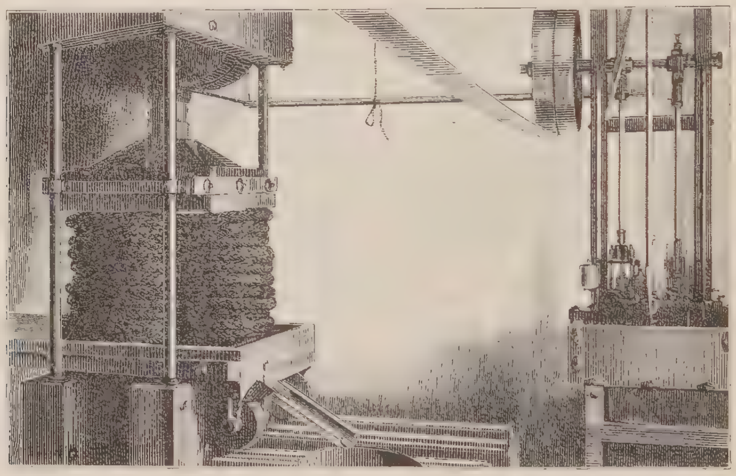

FIG. 93.—Hydraulic olive press.

which perhaps are not always correct, as a good deal of uncertainty exists as to the proper names of many varieties of olives grown in California: Morinello, Infrantojo (Grossajo), Leccino (very resistant to cold), Razzo, Oblonga,[1] Uvaria of Mr. Loop (ripens early), Rubra, Morajolo (requires rich soil), Correggiolo (requires rich soil), Frantojo (said to do well on hills), Piru No. 1 (ripens early in November), Nevadillo Blanco, and Mission. The following are especially excellent for pickles: Ascolano, St. Agostino, Oblonga, Sevillano, Picholine, Manzanillo No. 1 of Mr. Roeding (not of Tablada), Lucques (ripens very early), Ojo de Liebre (?) of Mr. Rock, Nevadillo Blanco, Mission (fruit small), Macrocarpa (only for warm, dry, and elevated situations;

[1] In 1894-95 a 54-year-old tree of this variety at Biggs, Cal., bore the heaviest crop of any tree of its age which has come under the observation of the writer, its product being 52 gallons of fruit.

ripens in October), and Palymorpha of Roeding. The two last named are quite apt to decay at the pit.

EXTRACTION OF THE OIL.

The extraction of oil from the olive is a purely mechanical process. In California two general plans are followed in preparing the olive pulp for the press. One is to grind the pits of the fruit with the flesh, and the other is to grind the flesh from the pits without crushing the latter. As the result of experience and various chemical analyses, it has become quite generally understood that the pit contains little oil, and that the practice of grinding it with the flesh tends to detract from the quality of the output.

Most of the mills now used for preparing olive pulp are made of cast iron, the crushing being done by a series of rollers. The presses used for extracting olive oil are of many patterns. Some growers use powerful screw presses, while others prefer the hydraulic press. Homemade lever presses, like the old-fashioned cider press, are still in use by some, and can be relied upon to do good work (fig. 93).

The olive pulp as it comes from the mill is placed in sacks for pressing. There are several styles of sacks in use, the French being made of fine fibrous grass, while those preferred in Italy and Spain are of coarser material and looser construction. The sacks are made in the form of a cheese, and are open at the center of the top and bottom for filling and cleaning. In preparing for pressing, a series of wooden slats, forming a kind of grating, is first laid on the bottom of the press. Over this is placed a perforated, circular plate of iron, on which is laid one of the grass mats or sacks. The pulp is then crowded into the sack until it is full. Upon the first sack is placed another perforated iron plate, more wooden slats, and then another sack to be filled. This is continued until six or eight sacks of pulp are placed one above the other ready for pressing. A number of California growers do not use grass sacks on account of the difficulty of keeping them thoroughly clean, but instead employ a Russian crash, cut into circular pieces about 3 feet in diameter. A galvanized-iron hoop, of the breadth and depth of the cheese desired, is first placed on the wooden grating. Over the top of this hoop is spread the piece of crash, and upon it is poured the olive pulp until the hoop is packed. The sides of the cloth are then turned over the pulp and the hoop is withdrawn. A slat grating is now placed on the cheese and the process repeated.

The first pressing of the olive pulp is done slowly and with caution, and the resulting oil, which is frequently known as virgin oil, is usually, on account of its superior quality, kept separate from that of the second and third pressings. When the oil ceases to flow after a thorough first pressing, the pulp is removed, left until next day, and

then reground and re-pressed. If desired, water may be added to the second pressing, but the oil thus obtained is of inferior quality. A third crushing and pressing, with the use of hot water, may be given to obtain the little remaining oil, which is of the lowest grade.

The subsequent clarification of the oil involves two general processes, namely, its separation from the watery juice of the fruit and from fragments of tissue by means of gravity, and a special clarification by means of filtration. There are scarcely two mills in this country which use the same vessels for the separation of oil. The form of the settling tanks, as well as their size and the material of which they are made, varies widely. Tin, wood, or stone vessels may be used successfully if kept perfectly clean. Tin vessels are probably most commonly employed, though some producers insist that white oak tanks are better. Whatever form or kind of vessel is chosen, the expressed olive fluids are allowed to stand in it until gravity has caused the oil to rise to the surface. As the oil rises it is either removed and placed in other similar vessels for further separation of impurities or else is stored in tanks to remain till ready to bottle.

The process of clarification by filtration, which usually follows the separation of the oil by gravity, varies. The clearest and most brilliant oil is, however, usually obtained by passing it through some compact filter, such as is used for filtering spirituous liquors, or the firm, gray filter paper commonly sold in circular sheets by druggists. A less brilliant oil may be obtained by passing it through more porous filters. It is even probable that oil bottled without filtration, if thoroughly cleared by standing at a proper temperature for a sufficiently long time, will be of a finer flavor than that passed through filters.

Cleanliness is a most essential feature in making olive oil, as this oil readily absorbs all taints and odors. No offensive smell and no tobacco or smoke of any kind should be allowed about the oil house, and everything in the building—mills, presses, cloths, dishes, tanks, etc.—should be kept scrupulously clean by washing daily with boiling water, and when possible with lye also.

In all the processes of expressing and handling olive oil it is important that it be kept at a moderate and uniform temperature and that it be not exposed to the light more than is necessary.

The gathering of olives at a proper stage of ripeness is an important feature of the olive industry. The olives should not be allowed to hang too long, but should be gathered while red. The best oil comes from olives not overripe. With late varieties there is also the advantage in early gathering that much risk from cold weather is avoided. Olives which have been frost-bitten should be sent to the mill at once. In gathering, the olives should not be allowed to remain on the ground more than a few hours, if at all, and all imperfect and bruised fruits should be culled out, as well as those which are overripe. The latter

may be put through the mill by themselves and the product kept separate. The fruit should be picked at a stage of ripeness as nearly uniform as possible. After being gathered, the olives should be spread out on trays in thin layers, so that the air may circulate freely among them, and the trays should then be kept in a dry, clean, and airy room. The fruit on the tray should be turned over every two or three days for twelve or fifteen days, or until it is properly dried, after which it is ready to be reduced to pulp in the mill.

OLIVE PICKLES.

The pickled-olive industry of California is growing rapidly from year to year. Two classes of pickles are prepared—the green and the ripe. Green olive pickles are more easily made than ripe ones, and, as a rule, will keep better. As a food, however, they are incomparably inferior to pickles made from the mature fruit, the oil of the ripe olive adding very greatly to its nourishing qualities and to its flavor. For consumption within the year nothing but mature fruit should be put up. Ripe olives may also be kept for several years if sufficient care is given to the pickling. For long keeping and for shipment the immature fruit is often preserved, especially by Europeans.

In gathering mature olives for pickling, they should be as nearly as possible of uniform color and ripeness, and it is desirable to pick them into water so that the fruit will not be bruised. The mature fruit should never be overripe, but for the best results it should be gathered while still firm and hard. Following the pickling of either mature or immature olives it is well to hand grade them for size and color and always into water.

Nearly all fresh olives are exceedingly bitter, and if preserved in that condition would be unfit for food. There are two methods in use for removing this bitter taste. One is to destroy or neutralize it by the use of strong alkaline solutions and the other is to wash it out gradually by the long-continued use of fresh water. The former method is that now most generally practiced by olive growers. The details of this process may be sought in special treatises, as it differs among different growers. It consists essentially in subjecting the fruit for some hours to the action of a solution of water and concentrated potash lye. This is usually in the proportion of 1 pound of lye to 8 to 10 gallons of water. The olives are allowed to remain in this solution until all bitterness is removed, or until the alkali has penetrated to the pit, which can be determined by the change in the color of the flesh. If one soaking only is given, it requires at least twenty-four hours, the fluid being agitated at frequent intervals by drawing off some and pouring it back so as to keep the fruit from spotting. When the bitterness is gone, the alkali is removed by soaking the fruit for a week or more in water, which is renewed quite frequently the

first day and at least once every twenty-four hours thereafter. Litmus paper may be used to determine when all the alkali has been removed. The fruits are now covered with a weak brine, which is allowed to remain on them for a week or so, and then with a stronger brine. Mr. Lelong advises three brines, containing, respectively, 4, 8, and 14 ounces of salt per gallon of water. To prevent the olives from becoming rancid, this strong brine must also be changed after it has become colored by the pulp of the fruit. If strong brine were put on at first, the olives would shrivel and be spoiled. To avoid a dangerous softening of the fruits, especially the riper ones, Mr. Lelong recommends two or three soakings in the alkaline solution, each for four hours, the olives to remain in the fresh water for several days between each treatment. During these treatments great care must also be taken that the fruits do not become crowded together and squeezed and in this way become disfigured and unattractive. This is best prevented by treating them in shallow vats. After the scum has ceased to rise from the brine, the olives are ready to bottle or to store in kegs. The brine used for bottling is of the same strength as the last used in pickling.

The process of extracting the bitterness of the olive by means of pure water usually lasts from thirty-five to sixty days, and during this time the water should be changed twice a day to prevent the development of bacteria and the spoiling of the fruits. In this process pure water is a great desideratum, and the value of distilled or boiled water can not be overestimated. No oil is lost by this process, and it also has the advantage of preserving the natural taste of the olive to a much greater degree, thereby insuring more delicious pickles.

This process of curing the olive, however, is not popular, owing to the amount of time and attention required to insure success. In this connection the writer would suggest that if artesian or spring water can be had and if the tanks are properly arranged with inflow and outflow traps or valves the amount of time required from the grower can be reduced to less than is required by the lye process. It would be a very simple matter to so arrange the water supply that a barrel could be drawn from the bottom of the tank every hour or two and the same amount allowed to enter at the same time at the top, direct from the spring or other source of supply. If the inlet is constant and limited, the valve at the outlet could be worked automatically by means of floats. The whole could be arranged after the manner of an automatic flusher and very little personal attention would be required. The main feature to be considered would be the proper arrangement of the supply pipes so that the water would always be too cold for the rapid increase of bacteria and would not be exposed to the air before its discharge into the vats.

At present pickled olives are put up on the Pacific Coast in bottles, kegs, half barrels, and barrels. Those put up in bulk are usually

sold to consumers by the quart or gallon. Prices vary according to quality and the laws of supply and demand, being commonly retailed from the barrel at from 15 to 25 cents per quart.

DISEASES OF THE OLIVE.

The diseases of the olive are quite numerous, but fortunately those most destructive to the fruit are not yet known in the United States. The most important olive trouble in this country, so far as observed, is the black scale (*Lecanium oleæ*). The control of this parasite may be most easily accomplished by treating the trees with resin wash at the time all the eggs have hatched. This will vary from year to year and in different localities, and should be determined by keeping careful watch of the insect itself, lifting the scale and examining it for the eggs, which are deposited beneath the parent insect. It will be found advisable to keep trees clean by early spraying rather than to delay until they are badly infested. One advantage of this is that it will prevent the tree from becoming infested with the sooty mold, a fungus which always follows the work of the black scale, and which is hard to remove from the foliage.

There are two insect enemies common in the Mediterranean region, which it is to be hoped may not reach this country. The more destructive of the two is a fly (*Dacus oleæ*), which stings the olive and the larva of which greatly injures the fruit. The olive crop is sometimes much affected in Italy, Sicily, and Spain, and to some extent also in France, by the depredations of this insect. The other insect is a moth (*Prays oleællus*), the larva of which feeds, according to the brood to which it belongs, either upon the leaves, the fruit buds, or the fruit. The larva of the last brood, which lives within the fruit, causes the latter to fall from the tree. The olive is greatly injured by each of these insects, as the writer can testify from personal observation, and every precaution should be taken to prevent their introduction into the United States. No fresh olives should ever be imported, and all truncheons, or cuttings, should be disinfected in a manner thorough enough to kill all eggs and pupæ which may be upon or under the bark.

A tubercular swelling of the smaller limbs and twigs is common in some parts of Europe, but as yet has not been seen in this country. It is due to a bacillus, and the disease may be spread by inoculation. The excrescences, or tumors, characteristic of the disease are quite variable in size, but in most cases they mature before being quite an inch in diameter. Many branches cease to grow wholly or in part beyond the swellings after the latter have become partially developed. Some branches become stunted, while others die entirely toward the end, hence, the growth of the tumor is largely limited by the life and vigor of the limb bearing it. As a means of preventing its introduction, all imported olive branches should be carefully inspected by

someone familiar with olive diseases and all diseased branches or wood condemned and burned. There are many other European diseases of the olive due to fungi or insects or to physiological troubles. There are also several diseases of the fruit, leaves, and bark now present on the Pacific Coast, but none of these are at this time causing any serious losses.

[NOTE.—The Census of 1890 reported the total olive production of the United States the previous year as having a value of $386,368 in the primary market. The whole of this production was reported from the State of California, which, with 278,380 olive trees in bearing, contained within its boundaries the entire olive-growing industry of the United States. Of these trees, 79,208 were in Los Angeles County, 58,340 in Sonoma County, 29,688 in Alameda County, 22,747 in Santa Clara County, 20,595 in Fresno County, and 10,436 in Butte County, the remaining 57,366 being distributed over 31 counties, extending as far north as Tehama, with 1,673, and Shasta, with 687, trees in bearing. The Eleventh Census also shows there to have been at that time 331,022 olive trees set out that had not yet come into bearing, 328,997 of them being in California, and the remaining 2,025 in Arizona. Although these trees should in the ordinary course have doubled the crop during the period that has since intervened, the imports of olives during the last seven years have been annually from one and one-half to two and one-half times as great as they were in the census year, when they amounted to $211,817, or less than three-fifths of the value of the domestic crop. The imports of olive oil, or what passes for such, were greater in the fiscal year ending June 30, 1896, than ever before, being 942,598 gallons, of a declared value of $1,107,049. These various figures indicate the large possibilities that attend the cultivation of the olive in the United States.—EDITOR.]

THE USES OF WOOD.

By Filibert Roth,

Expert in Timber Physics, Division of Forestry, U. S. Department of Agriculture.

GENERAL REMARKS.

Wood, like soil, air, and water, has until recent times been one of those materials which man could obtain without effort beyond the mere taking. Hence, although it has become one of the most important, most generally used, and to our civilization most indispensable products of nature, our attitude toward its production has been one of indifference. Wood has been used so generally that a large amount of empirical knowledge regarding its properties has accumulated. This knowledge has sufficed for immediate purposes, and the need of a more intimate knowledge gained by investigation and experiment in regard to the properties and characteristics of wood has never become very apparent. Abundance and cheapness, together with ignorance of its true merits, have led to a most extravagant and often erroneous use of this product. We have witnessed with indifference, also, the useless destruction of enormous quantities of timber in the vague belief, characteristic of the times, that when the supply is gone some substitute will be found. That this belief is poorly founded is quite apparent, for while such substitution as, for instance, that of iron in ship, bridge, and track construction has taken place, and undoubtedly will continue and even increase in many directions, it has not prevented, even in countries like England, where wood is dear, an increased consumption per capita of population, while Germany, with all its well-managed forests, imports great quantities of large-sized timber. Moreover, as we learn to know the properties of this material, we find that it is capable of many uses for which it was supposed the metals alone were fit; wood is to-day displacing the best qualities of steel even in such delicately balanced structures as the bicycle. That this return to wood in many of our manufactures will continue, in spite of the cheapness of iron and steel, there is not the slightest reason for doubt, and the importance of wood as a material of construction, to say nothing of its use as pulp, cellulose, and its derivatives, and its growing value as a fuel, will steadily increase and not decrease, as is so commonly assumed and taught.

Before entering into the discussion of the uses of different kinds of wood, and the reasons for their selection, it may be well to review the principal useful qualities of this material and to some extent compare it with its most natural substitutes.

WOOD AS COMPARED WITH IRON.

1. Wood is a natural product; iron the product of a costly, complicated manufacture. Wood may be grown wherever man wishes to use it; the manufacture of iron is practically confined to particular localities. The mines of both iron and coal are exhaustible; the forest, under proper management, produces forever.

2. Wood is cheap; metals are dear. Even in the form of lumber, and with the cost of long-distance transportation added, wood costs the consumer in this country rarely more than 25 cents per cubic foot, while iron in bars and sheets is worth at wholesale from $5 to $10 per cubic foot.

3. Wood is soft; simple tools and small effort suffice to shape it. Iron is hard; any change of form, whether by casting, rolling, sawing, cutting, planing, turning, filing, boring, or grinding, requires much labor, or else complicated and costly processes and equipments. In the ease and rapidity with which wood can be shaped, reshaped, and combined in structures it excels all other materials.

4. Wood cleaves or splits; metals do not. While this property has its disadvantages, it is one that in some directions determines the usefulness of wood. It permits ready preparation for fencing and firewood, which latter use exceeds in bulk ten times the amount of iron and steel used in this country.

5. Wood is stronger than is usually supposed. In tensile strength (pull lengthwise or with the grain of the wood) a bar of hickory exceeds a similar bar of wrought iron of the same length and weight, and it even surpasses steel under the same conditions.

Similarly, a select block of hickory or of long-leaf pine sustains a greater weight in compression endwise (parallel to the grain of the wood) than a block of wrought iron of the same height and weight, and nearly approaches cast iron in this respect.

6. Wood is very elastic and resists bending to a marked degree; and though the modulus of elasticity of iron as ordinarily stated appears 10 to 15 times as great as that of good ash or long-leaf pine, yet a square 10-foot bar of the latter wood requires 6 to 8 times as great a load to bend it by 1 inch as a similar bar of iron of the same length and weight. Moreover, wood endures a far greater distortion than the metals without receiving a "set" or permanent injury. It does not rust nor crystallize, but retains its quality, and being light, and therefore used in solid pieces, may be selected with perfect assurance of avoiding "flaws," which are so dangerous in all metals when used in small pieces combined to make a larger structure.

7. Wood is light; iron and steel are heavy. The average weight of all wood used in this country does not exceed 31 pounds per cubic foot; that of iron and steel is from 430 to 450 pounds per cubic foot. This quality affects ease of handling and transportation; it permits the floating of most woods when green and of all when dry, and with

its superior strength and stiffness results in a saving of more than 75 per cent in the weight of structures, frames, floors, furniture, etc.

8. Wood is a poor conductor of heat and electricity. Heated to 150° F. or cooled below the freezing point of water, iron, steel, and other metals are painful to the touch, and even far within these limits metal objects are objectionable on account of their ready conductivity of heat. Wood, on the other hand, is entirely inoffensive as long as its temperature remains within the above limits. The objections to metal dwellings on this account are experienced also in heavy-armored ships, which, in spite of the excellence of an oceanic climate, are notoriously uncomfortable and even injurious to health.

When exposed to heat, wood is ignited and destroyed by fire. The inflammability and combustibility of wood at high temperatures, though among its most valuable properties, are, at times, a drawback which metals do not share; nevertheless, during conflagrations the behavior of wooden structures is often less objectionable than that of metal structures; for, while a beam of wood burns, it retains its shape to the last, and the structure may stand and be saved, while under the same circumstances metal beams twist out of shape and thereby occasion the fall of the entire structure. This behavior of wood in conflagration has induced the best authorities, fire underwriters and others, to recommend the use of wood in all large structures where the combustible contents of the rooms annul the value of fireproof metal construction.

If wood were a good conductor of electricity, its usefulness as a material of construction in our large cities would be much impaired, for it appears to be a very serious and constantly growing difficulty to protect life and property against this dangerous and yet so useful force.

9. Woods are normally inoffensive in smell and taste; liquors and wines of the most delicate flavors are kept in oaken casks for many years without suffering in quality. Chemical changes, often directly producing poison, prevent the use of cheap metals for these purposes.

10. Owing to their structure, all woods present varieties of characteristic aspects and possess no small degree of beauty. A plain surface of metal, of whatever kind, is monotonous, while one of wood, unless marred by paint, presents such a variety of unobtrusive figures that the eye never tires of seeing them. That this beauty is quite fully appreciated is best illustrated by the fact that pianos, sideboards, and other elegant furniture are not covered with sheet metal (as they might very cheaply and effectively be), and that the handsome floors of costly structures are neither painted nor carpeted.

11. Wood is easily and effectively united by the simple process of gluing, so that valuable combinations, whether for behavior, strength, or beauty, are possible. A three-ply veneer board may not only be as pretty as, but also more serviceable than, a simple board of any one

of the two or three kinds of wood of which it is composed, and a white-pine door with cherry or walnut veneer is not only fully as handsome as a walnut door, but it is far superior in its behavior, since all shrinking and warping is thereby practically prevented. Iron and steel may be welded, most metals can be soldered, but none of these processes can be compared to gluing in effectiveness and ease of operation.

So far wood has been regarded only as a material of construction; but while this is perhaps the most important consideration, the use of wood as a substance which may be altered physically and chemically is far more important than is generally admitted.

12. The great mass of mankind is warmed and has its food cooked by wood fires. Even in this country to-day, in spite of the great competition of coal, three-fourths of all the homes and thousands of manufacturing establishments are supplied with heat from wood.

13. Wood is ground into pulp and made into paper and pulp boards with endless variety of application. Wood pulp, made by chemical processes, results in cellulose and its countless derivatives, which are capable of supplying almost anything, from a shirt collar to a car wheel.

14. Distillation of wood furnishes charcoal to the smithy or furnace, vinegar to the table, alcohol to the artisan, creosote to the wood preserver, gas for fuel and light, tar for roof boards, and pyroligneous, oxalic, acetic, and other acids, as well as acetone, paraffin, naphthalin, etc., to the manufacturing chemist, and, by a slight variation of the process, lampblack to the printer and painter.

Wood also differs from the metals in several other respects. It is not fusible, it can not be cast; hence, to duplicate a form in wood requires the same amount of effort as did the original. Changed into pulp, and still more into cellulose, this drawback is largely overcome. Wood can not be welded, though, as stated before, this is more than compensated by gluing; nevertheless, an end-to-end junction of the kind produced in iron can not be effected.

Wood can not be rolled; it must be cut into shape; but owing to its softness and cleavability this requires incomparably less effort and equipment than the rolling of metals.

Wood is hygroscopic; it contains water under all ordinary conditions, and the amount so contained varies with external conditions and with it the dimensions of the piece. Though an advantage in a barrel or tube, by making it more secure against leakage, this peculiarity of wood is nevertheless a drawback not belonging to the metals, but corresponding to the drawback in the use of metals occasioned by their annoying expansion and contraction due to change of temperature. Wood decays; iron and steel oxidize or rust. Both are serious drawbacks to the use of these materials, but since decay depends on living organisms, whose multiplication is sometimes extremely rapid, at other times almost imperceptible, varying with the conditions of

the wood (moisture, temperature, etc.), the decay of woods is generally more damaging than the oxidation of metals. Under water wood lasts longer than steel or iron.

WHEREIN THE WOODS DIFFER.

The properties which directly or indirectly lead the artisan to prefer a particular kind of wood for a special purpose may be grouped into—

1. Mechanical properties, such as strength, toughness, stiffness, etc.
2. Physical, such as weight and behavior during and after seasoning.
3. Chemical, such as color, durability, and value as fuel.
4. Structural, such as texture, beauty of pattern, and length of fiber.
5. Biological, such as size, form, and abundance.

MECHANICAL PROPERTIES.

Of these several groups, the mechanical properties naturally take precedence, and of these again toughness and stiffness are unquestionably the most important, so that even the most general classification of woods into "hard woods" and "not hard woods" (for this latter class, though by implication the conifers, has so far no name in this country) depends not at all on hardness as the word might suggest, but on toughness, the tough woods being the hard woods, the others the conifers. Since toughness is a combination of strength in several directions, the various forms of strength should be first considered separately.

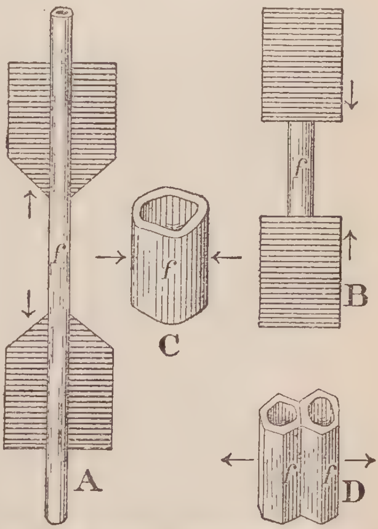

FIG. 94.—The four fundamental forms of resistance: A, to tension; B, to compression parallel to fiber; C, to compression at right angle to fiber; D, to transverse tension; *f*, fiber of wood. Arrows indicate direction of force.

When in use, wood usually breaks in bending, as in the case of an ax or fork handle, or else in shearing or splitting, as seen in planks and boards, whether on the sidewalk or in the wagon body. Wood fails much more rarely in compression, though much exposed to this form of strain, and still less frequently in tension, since in this direction its resistance is enormous, and can, in ordinary articles, never be brought to fair trial.

Fundamentally, all strength of wood depends on four different forms of resistance, namely, the resistance to tension, or lengthwise separation of the fiber (fig. 94, *A*), resistance to compression lengthwise (fig. 94, *B*), resistance to compression sidewise, or to collapse of fiber (fig. 94, *C*), and lateral adhesion of the fibers (fig. 94, *D*). Where a stick of wood is tested, none of these forms of resistance can

be isolated and tested separately, and in every kind of failure two or more are represented.

Since the strength of the fibers in adhesion is very much less than in tension and compression, adhesion enters into nearly every test as an important factor.

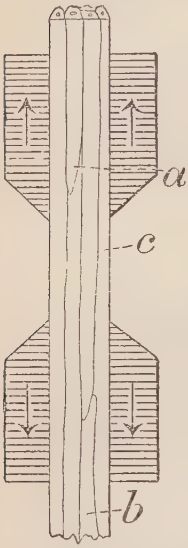

FIG. 95.—Behavior of fibers in tension test: *a*, *b*, ends of single fibers, which may be pulled out; *c*, whole fiber, which must be broken.

Thus, if a piece of wood consisting of several fibers is tested in tension (see fig. 95), the fibers *a* and *b* would probably not break at all, but be merely pulled out, the failure, as far as they are concerned, being due to lack of adhesion and not to a lack of tensile strength. Every tension test presents numerous cases of this kind, the broken fibers presenting no even fracture, but being splintered and drawn out, especially if the wood is good.

In the same way when a piece of wood is compressed lengthwise, some fibers badly situated with regard to the action of the load collapse or else crush into their neighbors (see fig. 96), and immediately a breach develops, into which fiber after fiber falls, the breach spreading from this point; and the whole mass of fibers, now no longer adhering in this plane, behave as a great number of separate fine strands—they "buckle," and the piece fails.

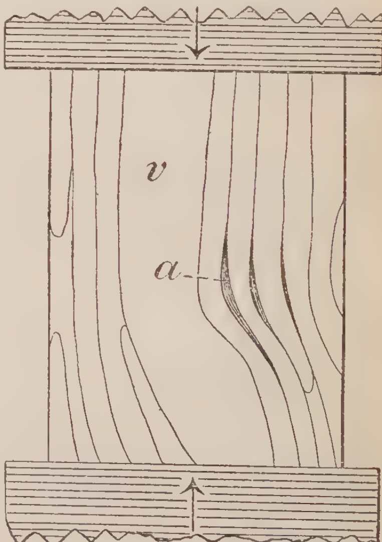

FIG. 96.—Beginning of failure in compression: *v*, vessel; *a*, point where the fibers are separating and the "buckling" is beginning.

Bending is a compound test of compression on the upper (concave) side of the beam and tension on the lower (convex), and numerically stands between these two, that is to say, if a stick breaks in bending, whether it break first on the upper side (in compression) or on the lower side (in tension), the bending strength, as commonly stated, is neither equal to the compression strength nor to the tension strength, but lies between the two. Here, as in the cases cited, adhesion forms one of the factors, since at failure part of the rupture consists in a separation of fibers.

Shearing along the fiber is simply a test in adhesion, where the force acts in a line parallel to the fiber, and the values in shearing wherever tested agree with those of tests in "transverse tension," as the test of adhesion may be termed.

In splitting or cleaving, the case is, like shearing, almost entirely one of transverse tension; with this difference, however, that the force is applied to a small area and acts on a lever (the side of the cleft); it acts, therefore, the more effectively the longer the cleft and the stiffer the wood. From what has preceded, it is evident that the adhesion of the fibers, or, better, the resistance to transverse tension, is of great importance. Examining the structure, it is quite apparent that this resistance is greatly influenced by the shape and relative position of the fibers. In hard woods (see fig. 97) the cells do not arrange themselves in rows; hence, there are no natural cleavage planes (except at the pith rays). A knife passing along the line *A B* in fig. 97 does not merely separate two layers of fibers; it has to cut through the cells themselves; while if passing through coniferous wood, as along *A B*, fig. 98, it finds a natural plane of contact of two sheets of fibers, and thus has easy work. Moreover, the course of the fibers in hard woods is rarely straight, the fibers are generally in oblique positions (best illustrated in elm), they "interlace," and if a piece of wood is split the surface is fuzzy with the myriads of fibers which were not merely separated, but were torn in tension, the very way in which they offer greatest resistance. For these reasons hard woods have generally a much greater strength in transverse tension than the conifers. Thus, oak excels hard pine nearly as 2 to 1. Where this greater resistance to transverse tension is accompanied by a greater flexibility, by more "give," as is nearly always the case with hard woods, the wood becomes tough; a blow may indent, but does not shatter.

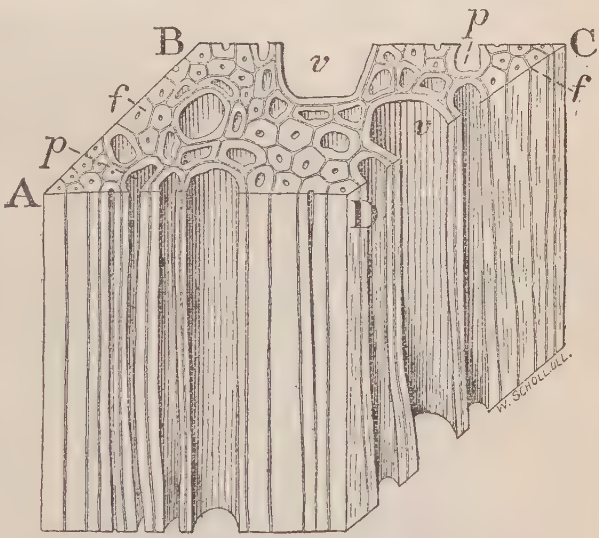

FIG. 97.—Typical hard wood: *f*, *f*, wood fibers; *p*, pores; *v*, *v*, cavity of vessels.

This toughness is a combination of relatively great strength in transverse and longitudinal tension together with a fair amount of flexibility or capacity to endure distortion. That toughness varies widely is well known, as is shown in the elm, which excels in toughness, and in the yellow poplar, which possesses but little. Naturally the hard woods exhibit it to a much greater degree than the conifers.

Even a poplar board will bear far longer the constant jar and jolt and wrench which it must endure as a part of a wagon box than a very strong piece of pine or other conifer, and great toughness, such as exists in a good hickory spoke, is not possessed by any known coniferous wood.

Hardness in wood means the resistance which any surface, but particularly the sides (longitudinal faces), offers to the entrance of a blunt body, such as a hammer. The test in hardness is one of transverse compression of the fibers, and therefore depends on their resistance to collapse. In a single fiber (see fig. 94, *C*) this resistance depends on that of the material (presumably about alike in all wood), on the shape of the fiber, and the relative thickness of its walls. Fibers like those of hard woods (fibers proper, see fig. 97), with a hexagonal cross section

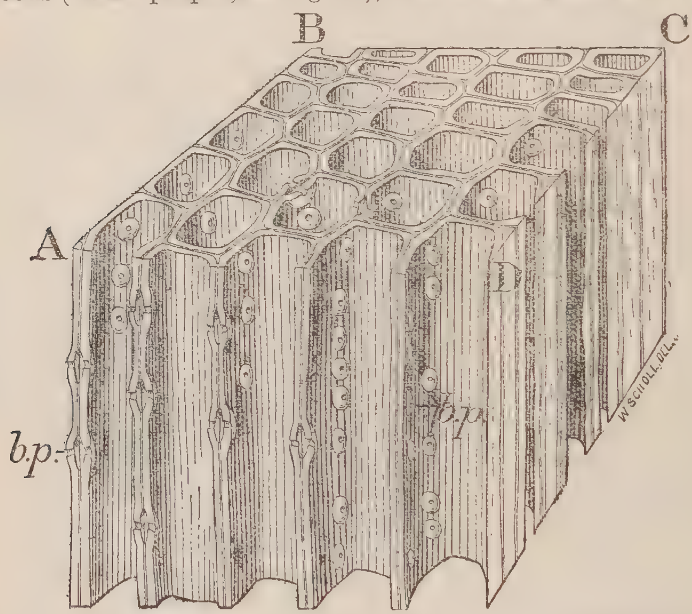

FIG. 93.—Typical conifer, drawn to same scale as hard wood: *b*, *p*, bordered pits, by which neighboring cells (tracheids) communicate.

and commonly scarcely any cell lumen or hollow, naturally behave almost like solid wood substance. They offer great resistance, so that if the outer surface of a stick is formed by such fibers its hardness is very great. If, on the other hand, the surface layer is composed of thin-walled vessels or of tracheids, like those of the spring wood in conifers, the wood is soft. In the usual test the indentation extends but a short distance ahead of the instrument (as, for instance, when a timber is struck with a hammer); but if the test is continued long enough the compression results in destruction of all the thin-walled and much of the thick-walled tissue of the wood, so that timbers, such as those sometimes buried in collapsed portions of deep mining shafts, are destroyed throughout. Such a crushed stick continues to resist further

crushing, becomes compacted, dense, and heavy, but loses nearly all its bending strength, etc.; it takes up water rapidly, and when soaked crumbles like wood in the later stages of decay. Closer examination shows that all thin-walled fibers have collapsed just like crushed pasteboard tubes, the break running along two or more lines the length of the fiber, the form of the cross section being changed from a hexagon to an S shape, or an approach to this form.

The hardness of wood in the sense as noted is quite variable, even in wood of the same species, varying on different sides and also according to the portion of the annual ring exposed at the surface, the extent of compression, and other circumstances.

In nearly all wood used for construction, whether a bridge timber, the studding or joist of a house, or merely a table or chair leg, the stiffness of the wood is an essential quality, and in many if not most cases it is far more important than the ultimate strength. Thus, a rafter or joist need not be very strong, but it must bend but little under its assigned load, and even in furniture and smaller objects the piece must not only be sufficiently large to hold up its weight without breaking, but to hold it without being distorted to an unsightly or troublesome degree. In this case ultimate strength is not considered, but stiffness or elasticity rather, and in the majority of cases a "strong wood" is, with the artisan, really a stiff wood. The stiffness of a piece of wood depends on its weight and on its structure. If a single fiber of pine (see fig. 99) and one of hickory, both of the same size and thickness of wall, could be tested, they would probably be found alike in stiffness, strength, and degree of extensibility, for both are practically alike chemically and physically. The great difference between these woods must therefore be in the combination in which the fibers occur in the wood structure, and it is in this that we find a ready and plausible explanation for differences. A glance at figs. 97 and 98, the one representing typical hard wood, the other coniferous wood, shows that—

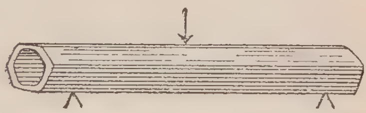

FIG. 99.—Single cell test in bending.

1. The elements of structure are alike in conifers, unlike in hard wood.

2. They are all large (comparatively) in conifers, while in hard wood extremely small elements (fibers proper) form scattered bodies among larger ones (parenchyma) and very large ones (the vessels).

3. These bodies of small fibers, the strongest part of the wood, have extremely thick walls, compared to their size, in the hard woods, but much less so in the conifers.

4. The fibers in conifers are arranged in perfect rows (or really sheets, for the cells of each row are practically conterminous), those of hard woods are found in divided bodies, and appear like separate

strands of specially strong material. In addition, the fibers (tracheids) in conifers are usually much longer than those in hard woods, a fact not shown in the figures. On account of these structural conditions the fibers in the conifer act much more perfectly together and allow less "give" than the heterogeneous elements and especially the separated strands of fibers in hard woods, which arrangement permits more "give," and this "give" lessens the stiffness or elasticity of the hard wood. For if we return to our single cell (see fig. 99) we would have the upper part compressed when the fiber is bent, the lower extended, and the behavior would simply depend on the shape of the fiber and the material of its wall, but if we have a set of fibers and vessels (see fig. 100) grown together and tested the behavior depends not only on their shape and the material, but also on the relative position of the fibers and other elements. Those which are crooked or oblique on the upper side of the stick will have their unfavorable attitude increased, those on the lower side will merely be straightened or but partly strained, while the main part of the load applied at first is borne by only a part of the fibers, that is, those straightest in their position. Here the large fibers of the conifer with their regularity of arrangement all fall in line at once, they are "straight grain,"[1] the "give" is small, and the timber is stiff. Moreover, when the load is removed the case is exactly reversed. The fibers of coniferous wood, all being strained, exert the same power to return, while many of the fibers in the hard wood, on the other hand, are really under but little strain, they make little effort to return, the timber does not "spring back," and thus is neither very stiff nor springy or resilient; it is not very elastic. Thus, it is that conifers are, as far as is known at present, generally stiffer than hard woods of the same weight, the difference often being very considerable. The finer and the more even the structure of the hard wood, the straighter the grain, the greater the weight of any wood, and the more perfectly it is seasoned, the stiffer it is. In conifers this quality seems to vary directly with their weight. In hard woods the matter is too little known to warrant any general statement, though here, too, heavy woods like oak and ash are stiffer than light woods, such as poplar.

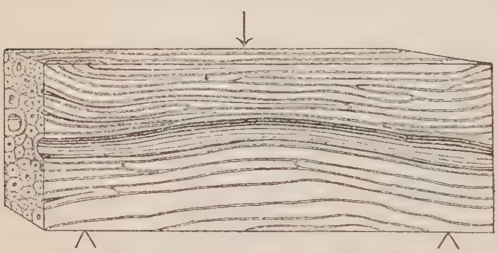

FIG. 100.—Behavior of hard wood in bending.

PHYSICAL PROPERTIES.

Weight is an important indicator of the mechanical qualities of wood and a direct measure of its value as fuel or material for coaling

[1] It must not be understood that coniferous wood is always straight grained in the ordinary sense of the word.

and dry distillation, and often determines the choice of woods for a particular purpose. Thus, panels and other surface lumber in vehicles, thrashers, and other movable articles, which should be no heavier than necessary to perform their function, and all lumber for shipping crates and boxes, especially where these must be tight and stiff, are invariably selected from the lightest wood obtainable.

Generally speaking, our conifers are lighter than the hard woods, but there are light and heavy kinds in both.

Shrinking, swelling, warping, and checking are the greatest drawbacks to the use of wood, and are all expressions of the same property of wood material, namely, its hygroscopicity, or capacity to absorb or give off water and thereby change its volume. All the walls of the cells grow thicker if a dry piece is moistened. This increases the size of the cells and thereby the size of the piece. The larger the single cell elements the more rapidly the water can get to or from all parts, and the nearer all cells are alike in size the more nearly they shrink and swell alike.

This explains why pine or other coniferous wood shrinks and swells much more evenly than hard woods, and also why they are more susceptible to moisture. It also accounts for the fact that the lighter hard woods give so much less trouble in shrinking and swelling than the heavier ones.

CHEMICAL PROPERTIES.

Since the chemical composition of the cell wall of all woods is quite similar, the value of wood as fuel and in dry distillation merely depends on its weight. Of the chemical properties important in construction, it is chiefly durability[1] and color which enter into the selection of materials, both dependent on chemical combinations. What the substances are which make the heart of cedar and white oak durable and what the processes are which lead to their formation are as yet but little understood. It is certain that these bodies are present only in very small quantities, but perfectly permeate the cell walls and commonly appear together with more or less sharply marked changes in color.

Generally, trees with durable wood form a distinct heartwood, but their sapwood is no more durable than that of other kinds. Since durability depends mainly on resistance to living organisms, proper experiments to determine the relative durability of woods are exceedingly complicated, and satisfactory results are still wanting. In the absence of better data, the "life" of railway ties as commonly observed will in some measure answer this purpose.

[1] Durability here means the resistance to decay when placed in the ground or otherwise unfavorably exposed.

Range of durability in railroad ties.

	Years.		Years.
White oak and chestnut oak	8	Redwood	12
Chestnut	8	Cypress and red cedar	10
Black locust	10	Tamarack	7 to 8
Cherry, black walnut, locust	7	Long-leaf pine	6
Elm	6 to 7	Hemlock	4 to 6
Red and black oaks	4 to 5	Spruce	5
Ash, beech, maple	4		

An even color, a darker or lighter shade, are such important elements in the appearance of wood that in all finishing work color is one of the chief considerations in the selection.

STRUCTURAL FEATURES.

Besides being intimately related to the mechanical properties, the structure also determines the texture and almost entirely the beauty of the wood. Texture may be said to be coarse when large pores, in rows or scattered, appear as holes on the ends or as dark streaks (troughs) on the sides, as in oak and ash; it is moderately coarse if all its elements are large, as in pine, and it is fine if all the elements are small, as in cherry, and much more so in boxwood. Apart from the appearance of the wood, the texture is often in itself a property which fits or unfits the wood for a particular use. Thus, red oak is useless for a faucet or for a delicate piece of carving, because in the one case it leaks, in the other its own coarse-texture lines will mar and distort the picture.

Structure is the first element of beauty in wood. Its uniformity of structure makes white pine monotonous; the striking difference of spring and summer wood renders hard pine obtrusive; the arrangement of vessels, fibers, and pith rays characterize oak, and the peculiar arrangement of the same elements gives to elm those handsome figures of dark wavy lines on an even background of brown.

Without analyzing or inquiring into their cause, the several patterns have become familiar to all, and our bedroom sets in oak and maple, cherry or walnut, testify to their recognition and importance.

BIOLOGICAL PECULIARITIES.

Size, form, and abundance of wood more than any other features have influenced the development of our wood industries. Man is indebted to the large, long-shafted, and well-formed conifers to a degree rarely appreciated for assisting him in his progress. Occurring on extensive areas and combining most useful qualities, they are generally sought for structural purposes. Masts of spruce and pine are carried across the seas, telegraph and other long poles of the same species are hauled hundreds of miles because of their form and the ease with which straight, elastic material can be found among them.

If a carpenter were obliged to rely upon beech, birch, chestnut, oak, poplar, etc., and had to use them in combination, house building would be not only much more difficult and costly, but unsatisfactory. While the stringer or joist of pine would keep straight, its neighbor, the oak, would sag down, the chestnut would warp out of line, the beech and hickory would soon be infested with boring insects, and the whole would be a failure. Abundance in suitable size, form, and qualities have made white pine the king of American woods, and so fully are these properties appreciated in practice that it required a severe struggle to introduce even such unexcelled material as cypress as a substitute.

WHERE AND HOW WOOD IS USED.

Though the consumption of lumber and timber in the various trades is enormous in this country, yet nearly three-fourths of the twenty-five billion cubic feet of total consumption still finds its way into the fireplace or is employed for fencing and other minor uses.

For these purposes almost all kinds of wood are used, though quite a selection is made wherever choice exists. Thus, in many of the better-wooded districts only the heavier hard woods, and often only the better second growths of these, furnish a marketable cord wood. Fencing is normally made from the wood on the land to be fenced, but the combination of durability, ease of cleavage, and lightness leads to preference of chestnut, cedar, etc., provided these can be had; otherwise any and all kinds are used, and much fencing is made of sapling poles and brush, notwithstanding the rapid decay as well as inferiority of such material.

But little more care is necessary in the selection of timber for rough constructions like log houses, barns, and sheds. In these cases timber of such large dimensions is commonly used that its mechanical properties are never greatly taxed, and the principal properties desired are ease of shaping and durability, and even this latter is deemed requisite only for foundations and unprotected portions.

CARPENTRY.

Among the woodworking industries that of carpentry, with nearly $300,000,000 worth of annual product, is, in this country, by far the greatest consumer. The material for this trade furnishes employment for most of our lumber and planing mills; it is generally sawed into standard sizes, much of it planed, matched, and otherwise finished. In carpentry we may distinguish between the covered or rough portions, such as the framework of a house, including sills, studdings, plates, joists, rafters, sheathing, and roof boards, and the exposed parts, such as the floors, doors, window frames, sash, blinds, and any stationary furniture, as store and office fixtures. For the former the wood must be abundant, in suitable, preferably standard, sizes, for

any cutting involves extra labor and waste, any splicing adds to the cost and deducts from the value of the product, and it is fair to say that the excellence, cheapness, and rapidity of American carpentry is in a large measure due to the development of uniform lumber standards. The wood for covered work should be straight, soft, or easily worked; it should be light, stiff, and insect proof, and should season rapidly without much warping. On the other hand, it does not require to be tough or very strong, for if properly designed and used, the full strength of the frame of a house is never put to test; it need not be flexible, cleavable, nor handsome, and, so long as it is kept dry, but little provision is requisite for its durability. It is readily seen that the combination of properties here desired is possessed to a considerable degree by all our common coniferous woods; and as a matter of fact entire houses are built of pine, or spruce, or fir, and everything from a sill to a shingle is made of every one of the many conifers in the market, not even excluding the hemlock. Where choice exists, the heaviest forms furnish the stiffest lumber, and may therefore be used in the smallest dimensions. Nearly all this wood is nailed or spiked in place, very little is framed by mortise and tenon, and none is glued together.

In selecting the lumber for the exposed portions of carpentry work great latitude exists. Aside from the floors, stairways, etc., where the hardness or resistance to wear establishes preference for hard woods, such as oak, maple, and birch, nearly the same qualities are demanded as for the covered work, with, however, the important addition of beauty, or satisfactory appearance, and a greater degree of hardness to protect against injury by denting and scratching. Though formerly a large part of this class of work was made of soft pine, the introduction of modern machinery, besides better taste and other causes, have greatly stimulated the use of hard pine and such hard woods as oak, ash, maple, birch, sycamore, gum, and elm, with a possibility of using almost every kind of wood grown in our forest. Generally, this finishing lumber, as it is commonly termed, is nailed to its place, the floors, ceiling, wainscot, etc., being tongued and grooved and thus in part framed together, while regular frame and panel work is used only for furniture, doors, and sash, and occasionally for ceilings and sides.

As in the preparation of lumber, the carpenter is greatly aided in this part of his work by numerous special industries. Standard sizes of doors, sashes, and blinds are made almost altogether in special factories; stairway railings, ornamental columns, all moldings, fancy floors, office and store fixtures are made in separate shops and require, on the part of the constructing carpenter, only the fitting and placing. In part of this work much artistic taste is displayed and the methods of the cabinetmaker are resorted to. Turned and carved decorations, the use of fancy woods—curly, bird's-eye, and other forms—(often

foreign woods) both in solid pieces and veneer, are employed, and the selection of the woods is much the same as in cabinetwork, though a greater range is possible, since in stationary parts the strains due to moving, etc., are avoided.

Enormous masses of wood are annually consumed on our highways, especially on railways, for wharves and piers, and large quantities also in mines. The hundreds of miles of wooden railway bridges and trestles and many more miles of common bridges, together with piers and wharves, are generally built of heavy timbers, either sawed, hewed, or in the rough, while smaller dimensions, chiefly 2 to 3 inch planks, enter merely as cover, and are usually wanting in the case of railway construction. Where foundations are made by means of piles, or large timbers driven into the soft ground, durability is always a much-desired property. Nevertheless, more than one-half of all the pile timber is pine, and only a minor fraction is of white oak and other durable woods. In brackish and salt water, where the timbers never have time to decay, but are attacked by the boring shellfish—the teredo—durability can be of but little importance and the wood is selected with regard to size, shape, and cheapness.

What has been said of piles applies to the larger part of all wharf and pier timber; durability is the most desirable quality sought, for the conditions are here always unfavorable to the preservation of timber. Generally no other demands are made. Ultimate strength, hardness, weight, and beauty, all are of secondary consideration in this kind of construction.

A large part of all mining timber serves the purpose of protecting the shaft against caving in, but great quantities are also used in the preparation of tram and rope ways, hoists, and other structures used in the removal of the products of the mine. Most of this material is used in large quantities at one place and in large sizes, and the avoidance of long-distance haul, usually costly in mining districts, abundance of proper sizes, and cheapness are of greatest importance. The bulk of mining timbers, both in this country and abroad, are therefore of coniferous wood, most commonly pine, locally hemlock, larch, cedar, etc., and occasionally hard woods. Timber for bridges and trestles, especially large structures, such as railway truss bridges, demands suitable form and size, great stiffness coupled with a minimum of weight, and also an easy, even seasoning of all the parts. These timbers are rarely seasoned when put in place, and a considerable warping of any parts would endanger the structure. Accordingly, the conifers—pine, spruce, cypress, cedars, etc.—form the principal bridge timbers, and hard woods are only used in exceptional cases. Bridge and trestle timber is usually sawed in standard sizes and large stocks of it are kept on hand by most railways. In placing them the parts are bolted together, all framing by mortise and tenon is avoided as much as possible, and the tensile strains are largely intrusted to

iron rods, while shearing or splitting from the ends is avoided by metal caps. In this way a great part of the timbers are strained chiefly in endwise compression, where again the conifers excel when the same weights of wood are compared. As in the case of wharf timbers, durability, though a desirable factor, is generally regarded as of secondary importance, and abundance in proper sizes and form, stiffness, lightness, and good behavior in seasoning determine the choice, though very perishable woods like beech, maple, and hickory are always excluded.

In all larger and more permanent work of this kind, iron and steel are rapidly displacing wood as a material of construction. These metal structures are not only more durable, but in case of bridges avoid the danger of fire, and being framed as far as possible at the factories may be erected in a remarkably short time.

ROAD BUILDING.

For the purpose of railway ties over 400,000,000 cubic feet of young and sound timber (mostly second growth) are annually required. Being largely buried in the ground (ballast), and therefore exposed to the most unfavorable conditions possible, most ties decay long before they are worn out, and durability, therefore, is the first consideration in their selection. Nevertheless, especially on large trunk lines with heavy traffic, ties are commonly injured by wear, not only to an extent which hastens the decay, but often to such an extent that the ties are worn out before decay has become injurious. In all such cases the ties require a considerable degree of hardness and toughness, or else must be protected by metal "tie plates." This valuable combination of durability, hardness, and toughness, together with great abundance, oak timber alone possesses, and fully 60 per cent of all ties are made of white oak (several species), pine, owing to its cheapness, following, while the rest are mostly cedar (several species), chestnut, and hemlock, the last named being chosen only on account of its cheapness. Railway ties are generally made from round timber, rarely from splits, hewed on two sides (top and bottom), more rarely sawed to size. On many of the larger roads an effort is being made to increase the life of ties by impregnation with metal salts or creosote, and also by protecting them against severe wear by means of metal tie plates. The substitution of metal for wooden ties, so extensively practiced abroad, has scarcely begun in this country.

Wooden blocks for pavements have been considerably experimented with, but their introduction in this country seems to progress very slowly. Both round and squared blocks are used; they are made 8 to 10 inches high, usually placed on a special foundation, the spaces filled with asphalt and other mixtures. Exposed to great wear and liable to rapid decay, the wood for this purpose should be quite hard and fairly durable. Less durable wood, such as beech, elm, pine, etc.,

is impregnated. Wooden pavement of badly selected sections of saplings of cedar or cypress, such as exists in Chicago and other places, is unsatisfactory in every respect.

SHIPBUILDING.

In shipbuilding, small as this industry is in this country at present, very large quantities of wood are consumed. Of the $29,000,000 worth of ships and boats built in 1890 about $14,000,000 worth were built of wood, the rest of metal. Rowboats, river barges, and kindred vessels are generally constructed of ordinary coniferous lumber, pine, spruce, fir, and cedar prevailing; in larger boats and most seagoing vessels, in which the hull is almost a solid mass of hewed rib timbers covered outside and inside with heavy planking, largely fastened with locust treenails, the rib frames, keel, and outside planking are made of hard woods, preferably oak, the inside planking and decking of coniferous woods.

Since not all immersed portions are subject to decay, such perishable woods as maple and birch, contrary to common belief, answer very well for frame timbers and planking. Cabins for crew and passengers, and framework for mast and machinery, are usually built of coniferous wood, the work resembling house carpentry; masts and other spars are made of conifers, usually pine.

As in the case of bridge work, iron and steel are rapidly displacing wood in naval construction, and by far the greater part of the better seagoing vessels are no longer made by the ship carpenter, but by the boilermaker, and the use of wood in shipbuilding is thereby limited to decking and finishing lumber.

JOINERY.

The joiner's trade, including furniture, cabinet, and box work, with an annual product of about $200,000,000, ranks at present next to carpentry as a consumer of wood. As in all other branches of industry, a great amount of specialization has taken place, and almost all our establishments manufacture but one line of goods, frequently but a single article. Though great difference exists in the work of these different establishments, the extremes are connected by numerous links, and any classification is accordingly imperfect. In the selection of wood for this industry we may distinguish between two kinds, the more important one, which must please the eye, and the less important, in which beauty is but a secondary consideration.

In addition to being handsome (a matter of taste), good furniture wood should be fairly hard in order to make a strong joint, prevent indentation, and assure a good polish and wear; it should also be fairly tough to avoid splitting, and for some parts quite strong to permit its use in small dimensions in spite of hard usage.

In recent years fashions in woodwork have sprung up; walnut, cherry, oak, maple, birch, elm, ash, gum, all have their admirers and

are rivals for predominance, and at present it may be said that any kind of hard wood which is offered in sufficient quantities and proper sizes will be acceptable to the furniture trade. In all better grades of work, curly, bird's-eye, and other figured woods, as well as foreign woods, are extensively used.

The second class of woods used in joinery is employed as covered or as body wood under veneer, as backs of cases, bottoms and sides of drawers, and for ordinary cheap chests, boxes, and crates for storage and shipping, of which about $50,000,000 worth are used each year. For these purposes all the lighter hard woods as well as conifers are used, and they are generally valued according to lightness, width, and freedom from knots. Most of the joiner's material consists of sawed lumber; chair rounds and legs, and a large part of the bent ware, are often made of split stock. All material is thoroughly seasoned, passing usually through the drying kiln before it is used.

In this kind of construction larger surfaces are paneled, both for appearance and the better behavior of the structure. Veneers, both sawed and cut, are employed in single layers on a soft-wood body, as on large cabinet pieces, both to save costly woods and to reduce weight, as well as to guard against shrinkage. They are also used for seats, etc., in double and triple layers, glued together and pressed while being glued into the particular form desired. Most of the wood is planed, but large quantities, especially in chairs and table work, are turned, and probably the greater part of all wood turning, as well as much wood carving and braiding (rattan and wicker work), is done in connection with this trade. Aside from packing boxes and crates, the great mass of this ware is joined by gluing; much of it is "dovetailed" and otherwise framed, and, unlike the carpenter, the joiner relies more on the screw than the nail.

Attempts to substitute iron and steel in furniture work are constantly being made, and iron bedsteads, and iron-framed seats for schools, churches, and parks are quite extensively used.

CAR AND WAGON WORK.

In the manufacture of wagons, carts, carriages, and cars, we may distinguish between those using wooden wheels, including all common vehicles, and those using iron wheels, usually running on tracks, including street and steam cars. The timber used in this trade may be divided into two groups, that used for wheels and axles, or the running gear, and that of the box or body of the vehicle. The former, especially the wheels of ordinary wagons and buggies, are exposed to harder usage than almost any other kind of wooden structures. Every mile of travel means thousands of jars, blows, jerks, and jolts to the wheels and to the entire running gear. Moreover, both hub and fellies must bear numerous large mortises to receive the spokes, and at all times the weight of the wheels as well as of the whole vehicle

should be as small as possible. For this reason the wood used in the running gear must be of the toughest and strongest, and hickory, oak, and elm are normally the wheelwright's woods. In good work, spokes, fellies, axles, and shafts are made of split stock, for which only the butt cut (lower 6 to 20 feet) of young or second-growth trees are used. A greater range for selection exists in the case of coarser work where larger sizes are employed, and here the fellies, tongues, bolsters, and axles are commonly made of sawed timber.

In its simplest form, as seen in the dray, cart, or lumber wagon, the body is a mere platform to hold the objects to be transported. In the carriage and car it becomes a house in which the goods or passengers are sheltered as well as conveyed. In the former case it consists merely of a few boards or planks, preferably of some light wood, screwed or bolted to crosspieces, together with movable or fixed sides and ends to prevent any material from falling off. In the latter, it is a large box more or less completely covered and supplied with doors, to which are added in the passenger car numerous windows and ventilators. Abundance of space, small weight, and great strength are demanded of all carriage and car bodies, and since the injury of the jars, jolts, and wrenchings to which these bodies are constantly exposed grows with their weight and size, they require careful construction and good material.

In general, such a body consists of a strong hard wood frame with panels or cover of thinner and usually lighter material. In carriages and passenger cars, particularly the lightly built street cars, where these frames are quite complicated and the dimensions of all but the bottom timbers reduced to the smallest possible size, and where, moreover, mortises are cut into almost every timber, only the tougher hard woods answer the purpose. Where timber is used in larger dimensions and the construction is simplified, as in freight cars, considerable hard pine is used.

Oak, especially white oak, and ash are the favorite timbers for framework; the cheap and thick covering is made of pine, panels and finishing work of yellow poplar, basswood, sometimes true poplar, also of ash, oak, cherry, walnut, mahogany, etc., either solid or in veneer. In this finishing work, taste and expense, even more than fitness, determine the choice of material, and the methods employed are those of the cabinetmaker. The wood for bodies is universally bought in the form of lumber or sawed timber, and its treatment is the same as in furniture work.

The amount of timber used in wagon and car work is very great. In 1890 the value of the total output of this trade was about $340,000,000, of which $205,000,000 fell to the manufacture of steam and street cars.

COOPERAGE.

Cooperage ware may be divided into tight packages, capable of holding liquids, and "slack" ware, intended for dry substances, such

as flour, cement, and lime. All cooperage ware is made in two distinct forms, the barrel-shaped, where the stave is bent longitudinally and cupped transversely, and the tub-shaped, where it is straight longitudinally and only cupped transversely.

In addition to resisting great mechanical stresses and rough usage, barrels containing costly liquors should impart no taste nor allow the liquid to ooze out, and thus be lost. Barrels being stored often for years in damp cellars, the material should also possess considerable durability and be insect proof. Of all common woods, white oak (several species) alone fulfills these requirements, and it is therefore the only material of which at present first-class wine and liquor casks are made. For inferior grades intended for oil, sirup, etc., other hard woods, such as red oak, maple, elm, ash, beech, and chestnut, are also used. Tanks, tubs, pails, churns, and other "straight-stave" ware, receiving much less hard treatment, are commonly made of coniferous wood—pine, spruce, cypress, and especially cedar. Slack barrels are made of almost every kind of wood offered in proper sizes, though here again the hard woods are preferred where great weight and hard treatment endanger the structure.

White-oak stock is usually split in the woods, ordinary stock and all slack-barrel stuff are sawed on special machines which imitate the splitting. For this purpose the wood is commonly bought by the cord in bolts of prescribed length, the staves and heads packed and shipped in sets, or else set up and sold as finished barrels.

Though wooden hoops are largely displaced by iron, much cooper's ware is still bound in hoops of ash, elm, chestnut, willow, and hickory. An output of $38,000,000 worth of ware for the year 1890 fully illustrates the importance of the cooper as a wood consumer.

FARM AND HOUSEHOLD MACHINERY AND IMPLEMENTS.

Though almost every article enumerated under this group is made by a separate special factory, it is, for the purpose in hand, convenient to group them under a common head according to their use. Here belong thrashing machines, fanning mills and windmills, harvesters and other reaping machinery, cultivators, plows, harrows, all kinds of dairy apparatus, washing machines and clothes wringers, ladders, and pumps; then also the smaller implements—hand rakes and forks, snow shovels, etc.

Most of these articles are subjected in their ordinary use to shaking, jarring, jolting, and wrenching, and while this amounts to little more than a strong vibrating motion in a fanning mill, it equals, in the case of plows, cultivators, or reaping machinery, the trying stresses borne by a wagon or cart.

In general, it may be said that all kinds of woods are used in the manufacture of these implements, by far the greater part being hard wood, and their selection depending solely on the mechanical

stresses to be met. Where these stresses are very great, as in plow beams or cultivator frames, and where, moreover, the timbers are extensively bored and mortised, only the strongest woods—hickory, oak, ash, and elm—meet the requirements. Larger machinery with extensive surfaces, such as thrashing machines, are built with a hardwood frame, made usually of ash or oak filled or covered with some lighter hard wood, such as basswood or poplar.

In the smaller implements the mechanical requirements are often very great; thus nothing but tough hickory makes a good ax or pitchfork handle. Where these stresses are less, ash, maple, elm, beech, and birch are permissible, and in such cases as broom handles even basswood and poplar. In almost all cases the conifers are excluded on account of their tendency to splinter and shatter for want of toughness. Most of the wood of these articles is bought as ordinary lumber, considerable quantities, especially of late years, being sawed at the sawmills for the particular purpose intended, and but little made from split stock. The industries here enumerated turned out in 1890 nearly $100,000,000 worth of product, of which perhaps one-fifth was for woodwork proper. Substitution of iron for wood and wood for iron is constantly going on in these industries as experience modifies the views of both consumer and maker.

WOODENWARE.

Under woodenware may be grouped the numerous articles made by the turner, the carver, and the split-ware industries independent of the large manufactures previously mentioned. Thus, the turner, in addition to his work in the joiner's shop and car factory, supplies spools, bobbins, and shuttles to the textile industries; handles for chisel, hammer, and file; shoe lasts and other form blocks; wooden shoes, artificial limbs, crutches, gunstocks, butter and other molds, and a host of other articles.

A good chisel handle should wear smooth, be hard to hold the tool, and be tough to resist splitting. Similarly a shoe last must be firm and smooth and not easily split or shattered by hammering; a faucet should not leak, and an Indian club or billiard cue should be firm, strong, and stiff, as well as of good appearance.

Of our woods, cherry, pear, apple, hawthorn, dogwood, persimmon, and walnut for finer wares; maple, birch, beech, blue beech, and ironwood for less decorative wares, and basswood, poplar, willow, red cedar, with occasional use of spruce, pine, etc., for light goods, form the common material; but there is no wood possessing sufficient hardness and a fair texture which could not well be employed in this trade. Turner's stock is both split and sawed to size, and great care is exercised in its seasoning.

Carving, in this country, is almost limited to the decoration of the products of the joiner, the car builder, and the shipbuilder; and many

of the articles formerly made by the carver, such as bowls, scoops, trays, shoe lasts, clothespins, etc., are now made by the turner. Carvers' material must have several distinct qualities. It must be sufficiently hard, strong, tough, and fine in texture to receive the details of form without breaking or splitting; its color and texture must be such that these details are clearly shown and the picture not marred by obtrusive peculiarities of color or structure of wood; and, lastly, it must also be hard enough to preserve the details under ordinary use. From this it is clear that the selection depends largely on the nature of the carving. In rough, cheap articles, with no fine details, any wood is good enough, and usually the softer kinds, like basswood, poplar, and even spruce, are used. Heavy ornaments like large bas-relief figures in church paneling are usually made in oak, in spite of its coarse texture. For small articles with minute details only hard, even-colored, and fine, even-textured woods like cherry, apple, dogwood, etc., can be used. The wood for these purposes is usually split from the log, requires perfect seasoning, and all larger-sized objects should be made of several pieces.

Wooden type for the printing of show bills, etc., also a kind of carving, requires a hard wood of even texture, and sugar maple is usually employed, though such woods as birch, holly, etc., would do equally well.

For the purpose of fine wood engraving none of our native woods seem to be sufficiently fine in texture, and foreign wood, chiefly boxwood, is used.

Split and veneer ware include the finer grades of wicker ware, made of split and planed willow rods, split baskets, woven ware for window shades, curtains, hats, etc., sieves, dry measures, matches, toothpicks, pegs, excelsior, also veneer boxes, plates, baskets, and crates.

Lightness, cheapness, and toughness usually decide the choice of material for these purposes, and though the easy splitting spruce and pine are worked up into splint baskets the result is never as satisfactory as if hard woods are employed. Poplar (both true poplar and tulip) and basswoods are the best of woods for this use, but where power and logs are cheap, gum, maple, birch, beech, and other fairly even-textured woods are cut, and the product is naturally superior in strength and wear. In these industries the wood is split or cut into veneer and strands while fresh, worked up at once, or dried and then usually remoistened when woven or put in shape. Any solid bottoms of crates and boxes are made of light pine and spruce lumber.

In pianos and organs the outer covering is made of fancy woods, foreign or native, solid or more commonly in veneer; frame and action of hard wood, particularly ash and maple, the latter being preferred for piano actions. Larger surfaces and veneer-covered body wood are pine, spruce, or other conifer, while the sounding-boards are almost exclusively spruce.

Among the miscellaneous consumers of wood, using relatively large quantities, may be mentioned the toy man, with his world in miniature. In this work, lightness and ease of shaping, coupled to as much toughness as possible, determine the preference for the lighter hard woods and particularly basswood and poplar, but spruce also and pine are extensively employed. Occasionally, however, the severe wear of the toys forbids the use of any but the toughest woods, and then hickory, oak, and ash are used, and in general in this line, as in the manufacture of implements, the woods are chosen to meet the expected mechanical stresses, only that toys should be as light as possible and are more easily pardoned for breaking.

MACHINE BUILDING.

Though wood has been almost entirely displaced in large machinery and the ancient trade of millwright has become a mere tradition, yet large quantities of wood still enter here and there in factory equipments, and it is noteworthy that wood is returning in many places where its displacement seemed a settled matter. Thus, wooden cogs for heavy gearing and wooden belt pulleys, besides other parts, are fast gaining favor. Where wood is used in framing, funnels, chutes, carriers, elevators, etc., the general principles laid down for kindred structures hold; where the frame is large and stationary hard and soft pine or other conifers serve well; if small, and especially if subject to much motion, shaking, etc., hard woods—oak, ash, and elm—are preferable. Panels and surfaces generally are made of conifers, if fixed; of hard woods, if there is much danger of shattering by rapid or violent movements.

WOOD PULP AND PRODUCTS OF DISTILLATION.

In the arts where the wood is not used as a solid, but its structure is destroyed, three processes may be distinguished:

1. The manufacture of pulp, by grinding the wood into small fragments, to be pressed together into sheets and used in the manufacture of paper, etc. It is desirable for this purpose that the wood have a light color to avoid extra cost in bleaching, and a long fiber to facilitate the felting and to give greater strength to the product. Spruce and poplar (several species) have generally been preferred, though pine, tamarack, fir, buckeye, and maple have also been used. In this process the chemical substances of the wood are not changed; its physical structure alone is altered.

2. In the manufacture of "chemical" pulp, where the wood is macerated by the use of acids or alkalies, its structure is not only destroyed, but also its chemical composition, a part of the substance being dissolved out and thus lost. The range of choice of material for this process is very much greater than in the preceding, there being no wood from which cellulose may not be obtained, though in practice woods containing much dark coloring matter or large

quantities of resin have so far been generally excluded. In addition to the woods mentioned for ground pulp, basswood, gum, cypress, and hemlock have been tried.

3. An entire chemical change is brought about in the "destructive" or "dry" distillation of wood. Here the wood is heated and made to undergo various combinations. More than half its substance is changed into a gaseous form, large parts of which are condensed into wood vinegar, wood alcohol, tar, etc., by cooling, while only about one-fourth is left behind as charcoal, retaining the structural form without its mechanical qualities, and radically changed in its chemical composition. For this purpose any and all woods can be used, and since the size of the wood affects nothing but the size and shape of the charcoal, small pieces (refuse, sawdust, etc.) are just as applicable as the best of log-size material. The products of this industry are such that enormous quantities can be used and their consumption can readily be stimulated by increased production.

PECULIARITIES OF OUR WOOD MARKET.

From the foregoing statements it may seem as if nearly all our uses of wood were satisfied by about a dozen kinds; that some of them, like oak, are "used for everything," and that the matter of selection is quite simple, the properties of these few kinds having been well known for indefinite time. This, however, is not the case, for it is our ignorance as to the relative merits, in strength and behavior, of the half dozen cedars, twenty or more pines, and equally numerous oaks growing in this country which causes their being here lumped together, compels the manufacturer and dealer in lumber to wrestle with the prejudices of his customers, and obliges these, in turn, to experiment and try each kind and case. It is this ignorance which, especially in the past, has been such a great obstacle to the introduction into the market of any new species or the more extended use of the well-known kinds, and has led to the exclusion of wood from many parts of its legitimate domain.

The market price of any kind of lumber depends at present only to a small extent on the excellence of the wood in the qualities inherent in it; it is governed chiefly by its range of applicability and other external circumstances. Among the latter are especially prominent the extent and character of the trade calling for the particular kind of wood, and the regularity and extent of the supply. Thus, white pine is used in such vast quantities, especially by carpenters, that we have in this country the reverse of the Old World conditions, and see the choicest hard woods go begging. In addition to this use in large quantities, white pine can be employed for so many special purposes that thousands of costly machines are constructed for its preparation, thus naturally augmenting its use.

The absence of sufficient wood industries near the woods and the consequent long haul to markets cause some very strange price lists. The following is an example, as taken from a journal:

Prices at Chicago, 1896.

Variety.	Prices per 1,000 feet, B. M.	
	Firsts.	Seconds.
Cheap woods:	*Dollars.*	*Dollars.*
Sugar maple	17	15
Soft maple	16	15
Basswood	18	16
Rock elm	16	13
Soft elm	18	16
Sycamore	15	14
Black ash	20	18
Valuable woods:		
White ash	26	24
Gum (sweet or red gum)	25	21
Birch	23	21
Poplar (yellow)	27	25
Chestnut and butternut	28	25
Red oak	27	25
White oak	26	25
Hickory	28	25
Costly woods:		
Cherry	70	65
Walnut	70	65
White pine		46

We have here the inferior chestnut ranking with and above white oak, red oak equal and superior to white oak, and such an excellent material as rock elm at the very bottom of all.

In general, it appears that the prices of hard woods are fairly independent of those of conifers, and that among the heavier hard woods oak determines the rating.

UTILIZING THE TIMBER.

What should be done with a large tract of marketable timber depends so largely on circumstances, such as the nature of the wood, facilities for logging, distance to and character of market, that it is impossible to give any directions of general applicability. The importance of reducing everything to the smallest possible weight, to save handling and freight, and also to increase the value of the product by careful selection and the greatest admissible degree of finish, is generally recognized, and the shingle and lath mill, as well as the planer and molding machine, have followed the sawmill to the woods.

While it is thus quite difficult to advise, a few suggestions as to the possibilities of timber exploitation may prove acceptable to owners of small tracts of timber land, and the following is intended chiefly to apply to small bodies of mixed hard woods, such as are abundant in the eastern part of the country.

Usually it is desirable to have some definite idea as to the quantity of timber standing on the particular tract of land. In most cases, especially if the timber is of large size, it is best to make a complete

inventory, excluding, of course, all young and useless trees. For this purpose the trees are counted, the different kinds of oak, ash, etc., being kept separate, and for each tree the following dimensions noted:

Diameter (inches) breast high, measured.
Diameter at top of saw-size timber, estimated.
Total height of tree (in feet), estimated.
Length of saw timber, estimated.

From the figures thus ascertained, the volume of the saw timber is obtained by taking one-half the sum of the upper and lower diameters, squaring, multiplying by the length of the timber (taken in feet), and dividing by 16,[1] the result being the amount of lumber wood in board feet. Of this about one-half must be deducted in ordinary hard woods for bark, slab, saw waste, crooks, and other defects.

The approximate total volume of each tree may be estimated by multiplying the area of the cross section (breast high, taken in inches), with half the total height of the tree taken in feet, and dividing by 144, the result being in cubic feet.[2]

Converted into cord wood, it requires 75 to 100 cubic feet of this solid measure to make a cord, or 128 cubic feet in the pile. In thickets of pole wood the amount of cord wood is often best estimated by counting the trees on a given area and noting how many 4-foot pieces an average tree will make, keeping in mind that it takes about 175 large-sized pieces, 200 medium or mixed, or else about 225 to 250 smaller pieces to make a cord.

Where considerable tie timber stands, the trees are best kept separate, noting for each how many ties it will furnish. Generally, trees under 12 inches in diameter are best left standing, unless they have special value for wagon or turner's stock, or else may be used for pulp. Special sizes or special kinds, such as walnut, cherry, yellow poplar, may often be sold in the log either to special manufacturers or else for export. Generally, this is not profitable. The bulky logs cost much to handle, and the buyer will deduct all wastage to the disadvantage of the timber owner.

In nearly all cases a sawmill of some kind is indispensable. This need not always be large; sometimes a portable mill worth $1,500 to $2,000 answers very well, and in some cases an arrangement may be made with a conveniently located neighborhood mill, although this commonly divides the interests to a troublesome degree.

The logging is usually best done in late fall and winter; labor is then more abundant, transportation locally facilitated by snow, and

[1] More correctly, take half the sum of upper and lower cross sections, multiply by length, and divide by 12. This calculation can be much simplified by the use of tables of circles, and still more by the use of such books as Scribner's Log Book.

[2] The process need not be repeated for each tree. Thus, if 30 trees have about the same general height, the sum of their cross sections is used to multiply into the length, etc., and the work can easily be much shortened.

the danger from fungi, causing discoloration and decay, as well as from boring insects, is at a minimum. Where this is not practicable, or where the bark is to be utilized, as in oak, all timber (cut in spring and summer) should be worked up as fast as cut, and any logs not at once sawed or split should be peeled, raised off the ground, and their ends painted. The particular product to be sawed depends on many circumstances. Along railways oak timbers are usually salable as sawed bridge and switch timber, car sills, etc., and timber of this kind deserves special attention, since it involves less labor in conversion and leaves little waste. All larger timber, especially of beech, birch, maple, chestnut, etc., may be cut into lumber, care being had to saw according to the quality of the log, for it is wasteful to saw a good log in a careless manner. Where sawed axles, bolsters, tongues, and other wagon stock are in good demand, these may be made, and rarely, in good timber, does careful quartersawing fail to pay for the extra labor involved. Whether the lumber is to be 1-inch or 2-inch stuff depends on the nature of the market and the wood, and a careful inquiry into what the dealer or consumer wants is in all cases of the utmost importance. The butt cuts of hickory, ash, elm, oak, and locust usually bring special prices as wagon and carriage wood, and therefore should be worked up into spokes and fellies, and otherwise shaped to suit the particular case. Where the market warrants, white oak may be split into cooperage stock, hickory into chair rounds and handles, birch sawed for spool wood, maple for all kinds of turner's materials, walnut for gunmakers, and much light wood is profitably converted into "shooks" or small boards, usually cut five-eighths of an inch thick, for barrels and boxes.

Many of the smaller woods, such as dogwood, hawthorn, and others, may be sold to the turner and cabinetmaker, and at all times burls, curly, birds-eye, and other specially valuable forms should receive attention. Smaller timber is preferably worked up into railway ties, for which only the more durable oak, chestnut, and locust are suited. Long, straight trees, especially of chestnut, are always in demand for telegraph and telephone poles, which, however, cause considerable trouble in handling and transportation. Tops and other refuse should be cut into cord wood, even if little more than expense is safely covered, for even in this case it furnishes employment and removes rubbish, which is always a nuisance and frequently a danger to the young growth, which should be left standing. Effort should be made to utilize all kinds of trees and all parts of every tree. Generally, it is easier and safer to convert trees into lumber only, since this is always salable, the largest trades all using wood in this form, but it is often more profitable to attend to the wants of other consumers and prepare wood for special uses, and even where this is not the case it may promote a more perfect utilization of all the material. In this connection

attention may be called to one of the common mistakes made by small concerns. It consists in neglecting both proper selection and care. The good should always be kept with the good, for it does not pay to sell the good with the bad, and in no case is it profitable or even excusable to spoil good lumber by bad piling, as is often done on unsuitable, damp ground, with no care as to ventilation or cover. A fair profit may easily be converted into a serious loss by neglecting to care for the board after it is made.

In oak timber the bark will usually prove a valuable source of revenue as tan bark. It should be peeled off in the spring and carefully dried, preferably under cover, since it molds if damp and is also injured by rain.

An illustration of what may be done by careful, systematic management is shown in the following particularly interesting case of timber exploitation, in no feature imaginary or theoretical, but actually carried out a few years ago:

Forty-three acres of well-stocked, rough timber land in eastern Pennsylvania were bought for $5,800, together with 48 acres of improved farm land, for which $2,500 additional was paid. A portable second-hand mill was purchased for $1,000; mill shed and shanties were erected, and this outlay, together with all the wages (nearly $4,000) and cost of hauling, railway and canal freights (little over $4,000), brought up the total outlay, land included, to $18,855. As the mill was at once set in operation, some income was derived from the first, thus obviating the necessity of considering the interest on the several expense accounts.

The following represents the cut from these 43 acres made in just two years, with only the partial personal attention of the owner and without the employment of a special superintendent:

Amount and value of articles and lumber sold.

		Sold for.
Miscellaneous:		
111 tons of oak bark		$1,224
801 cords of firewood		2,640
196 telegraph poles		500
16,800 hickory spokes		388
66,000 feet slabs (running measure), used largely in mines		333
For custom sawing		130
Sawdust		7
Total		5,222
Lumber (board measure):		
Hickory butts (bought by paper mill for cogs) feet	9,680	
Birch, sycamore, and second-cut hickory (sold to toy concern) feet	11,822	
Ash do	957	
Walnut do	3,414	
Yellow poplar do	12,941	
Gum do	1,386	

Amount and value of articles and lumber sold—Continued.

			Sold for.
Lumber (board measure)—Continued.			
Maple	feet	1,042	
Chestnut	do	34,719	
Oak	do	162,552	
Total		238,513	$6,522
Railroad ties	number	9,345	5,282
Switch timber	linear measure	6,217	821
Other materials			654
Total			18,501
Place and mill were then sold, the former at $4,623, the latter at $1,000, making a total of			24,124
Against an expense of			18,855
Leaving a profit of			5,269

Here was a tract of 43 acres of timber with a yield of less than 16,000 feet, B. M., per acre as ordinarily estimated; a stumpage of about $5 per 1,000 feet, and a profit of over $100 per acre. While it is not possible to repeat this everywhere, it goes far to explain why good hard wood timber in eastern Pennsylvania and New Jersey sells at $100 to $150 per acre when farm land does not bring one-half as much, while only 30 years ago the case was exactly the reverse and the farms were rated by the amount of "cleared" land. It also shows how, at least in a large part of the eastern United States, woods may be exploited in a careful instead of a wasteful manner, and how many a small holder, who can give the matter his personal attention and do much of the work at odd times, may make his wood lot a source of revenue.

In this case the object of the purchasers was simply to take from the ground and put into their pockets the money value which had been accumulating in the wood for centuries; and this they did without regard to what became of the ground after the crop was harvested. It was a speculation.

The farmer who owns his property not as a speculation but as an investment should go to work very differently in exploiting his wood lot. He should first determine whether his wood lot stands, as it should, on the poorer portion of the farm—the portion least fitted for agricultural purposes by reason of its rocky condition, its poor or thin soil, the steepness of its slope, or its location on a slope or hilltop where it helps to regulate the waterflow and prevent the washing of soil, etc. If it is so situated, and if therefore it is proper policy to keep the ground for forest crops—the only crops which can be profitable in such situation—then the cutting of the mature virgin timber should proceed in such a manner as to secure a desirable reproduction of the same, so that when the old crop is harvested a young crop is taking its place.

How this may be done merely by the judicious use of the ax in harvesting the old crop may be learned from the Department Yearbook for 1894, in the article on "Forestry for farmers," where the general principles are described, by the application of which such natural reproduction of the virgin growth may be secured. This would require a more gradual removal of the old crop, and all the cutting would have to be done with special regard to the needs of the young crop; in consequence the entire manipulation of the harvest, the disposal of material, and the financial arrangements would have to be modified, but the result can undoubtedly be made as satisfactory from a money point of view.

When the wood lot occupies desirable agricultural soils, the proper policy is to remove it, turn it into cash, and devote at least a portion of the proceeds to reforesting such waste portions of the farm as may be found on it, applying the principles outlined in the preceding article, "Tree planting in waste places on the farm."

It may be added that the study of how to use to best advantage all the material which grows in the forest, including the inferior kinds and inferior sizes down to the very brush, is as necessary to a profitable management of the wood lot and to forestry in general as the study of the conditions and methods by which the best development of the crop may be secured. To many it may appear that the time for such careful use of wood has not yet arrived; nevertheless, as in other agricultural pursuits, he who knows how to turn to account the small things is even now the most successful manager.

AMBROSIA BEETLES.

By Henry G. Hubbard.

GENERAL REMARKS.

Among the defects caused by insects in timber, known to lumbermen as wormholes, or pin holes, there are certain borings of small diameter, but frequently of great extent, which are distinguished by the stains which they leave in the surrounding wood and by the blackened lining of the burrows, which gives to them the appearance of having been bored with a red-hot wire. These black holes are characteristic indications of the depredations of a group of small elongate beetles, with compact cylindrical bodies, short legs, and dull brown or black coloration. The forms of two species are shown in figs. 103 and 104. In external appearance there is little to distinguish these beetles from their near relatives, the bark borers (Scolytidæ), but in habits and mode of life the two groups have little in common. The entrances to their galleries in the bark of trees are precisely similar, and the designation "shot holes" would be equally descriptive of either group. The variations in diameter are very well covered by the different sizes of smaller shot. The bark borers feed upon the wood which they excavate. Their galleries are superficial, lying within or just under the bark, and are packed with the wood dust which has passed through the bodies of the insects. The galleries of the ambrosia beetles, on the other hand, lie wholly within the wood, and in all their ramifications are of uniform size and free from wood dust or other refuse. Their food consists not of wood, but of a substance to which the name ambrosia has been given, and which is a coating formed by certain minute fungi and propagated on the walls of their galleries by the beetles. The action of the fungus produces the characteristic stain in the wood which serves to distinguish the galleries from those of all other deep-boring timber beetles.

About thirty species of ambrosia beetles, distributed in six genera, are now known to occur in the United States. Nearly all species and varieties of forest and fruit trees, together with many shrubs, are liable to their attacks, which fortunately seldom occur in vigorous plants, but are in the great majority of cases confined to those already dying of disease or which have suffered severe injuries. Nevertheless, there are among the number some which enter sound and healthy

wood. To very young trees and to small twigs and branches these may prove fatal by cutting off the flow of sap with an encircling gallery. In large tree trunks their attacks are seldom sufficiently long continued or extensive enough to endanger the health of the tree. Most of the species confine themselves in their borings to the sapwood; others, on the contrary, penetrate deeply into the heartwood and spoil the timber for any useful purpose by filling it with defects and promoting its decay.

THE FOOD FUNGUS.

The term "ambrosia," applied to the food material of these beetles, originated with Schmidberger in 1836. This writer, treating of a common European species injurious to fruit trees, declared that the food consists of a substance coming from the wood and elaborated by the mother beetle to form "a kind of ambrosia." Many writers have since indulged in speculations concerning the nature of this substance, but few of their number appear to have taken the trouble to examine it under the microscope. Theo. Hartig, in 1844, recognized and gave a name to the fungus. The same author in later writings pointed out that several distinct kinds of these fungi existed, and he conjectured that they were connected with the different sorts of timber in which he found them. In this, however, Hartig was in error. The different species of ambrosia beetles have each a particular species of fungus upon which they feed and which they are able to propagate in any kind of timber in which they may make their galleries. The food fungi of different ambrosia beetles do not mingle even when their galleries are in close proximity in the same tree trunk.

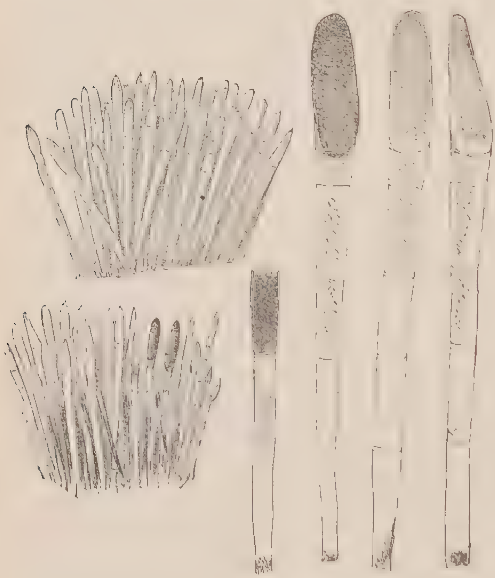

FIG. 101.—Ambrosia of *Xyleborus celsus*.

Much yet remains to be discovered concerning the nature and the propagation of these interesting fungi. Only a few of the many forms which probably exist have been investigated. Those which have been observed appear to fall into two categories: (1) Those which grow with upright stems, like mosses or coralines, and have at

the terminations of the stems and branches swollen cells, which produce spores, a representative of this class being ambrosia of *Xyleborus celsus* (fig. 101); (2) those which form chains of spore-bearing cells that break apart and accumulate in bead-like masses, a form of this class being ambrosia of *Corthylus punctatissimus* (fig. 102).

All the growing parts of the fungus are extremely succulent and tender. The spore-bearing cells especially are pellucid and glisten like dewdrops. When the plant is in active growth, these reproductive cells are produced in the greatest abundance and appear upon the walls of the galleries like coatings of hoarfrost. They are, however, exceedingly minute, and the details of their structure can be discerned only by the aid of a powerful microscope.

It is probable that these peculiar fungi have for ages been propagated by the ambrosia beetles, and through long association the plant and the animal have become completely dependent the one upon the other. Certain it is that the two classes of the fungi which have just been mentioned have very different habits of growth and of behavior under the cultivation given them by the beetles, and that these differences are closely connected with two distinct systems of rearing the young to be found among the fungus eaters.

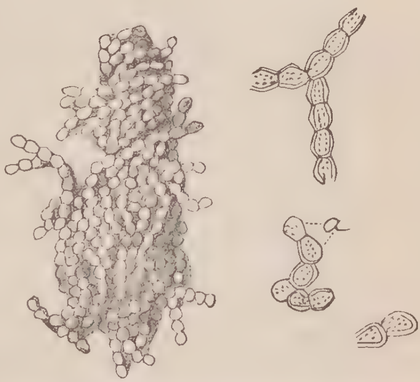

FIG. 102.—Ambrosia of *Corthylus punctatissimus.*

The spore-bearing cells of the moss-like forms, those growing upon upright stems, are quick to ripen and discharge their myriad spores. If neglected or broken down, the fungus beds quickly deteriorate and the plant disappears as if overwhelmed by a ferment. Like a bed of asparagus, it remains succulent and edible only when continually cropped, but if allowed to go to seed is no longer useful as food. The ambrosia beetles, which possess a fungus of this sort, feed upon it as it grows in the beds. The young larvæ nip off the tender tips as calves crop the heads of clover, but the older larvæ and the adult beetles eat the whole structure down to the base, from which it soon springs up afresh, appearing in little white tessellations upon the walls.

The young of the beetles in this case feed themselves, and consequently wander freely about the galleries in company with the adults.

The second class of ambrosia fungi, growing chains of cells which can be readily broken apart and transferred from place to place, is fed to the young by the parent beetles. The species which have ambrosia of this class raise their young in separate pits, and the mouth of each pit is kept closed by a plug of material from the fungus bed. As

fast as they are consumed, the plugs of food are renewed by the mother beetle.

Various disturbances of the conditions necessary to its growth are apt to promote the ripening of the fungus, and this is a danger to which every colony of ambrosia beetles is exposed. If through any casualty the natural increase of a populous colony is checked, there results at once an overproduction of the ambrosia. It accumulates, ripens, and discharges its spores, choking the galleries and often suffocating the remaining inhabitants in their own food material. The same result may sometimes be brought about by closing the outlets of the galleries through the bark, or by spraying into them kerosene or some other noxious liquid. The inmates of the colony are thereby thrown into a panic, the beetles rush hither and thither through the galleries, trampling upon and crushing young larvæ and eggs, breaking down the delicate lining of ambrosia on the walls of the brood chambers and puddling it into a kind of slush, which is pushed along and accumulated in the passageways, completely stopping them in places. The breaking down of the food fungus follows, and in a few days the galleries are filled with a paste-like mass of granules, or spores, or with threads of mycelium, in which the living insects are suffocated and destroyed.

The ambrosia does not make its appearance by accident or at random in the galleries of the beetles. Its origin is entirely under the control of the insect. It is started by the mother beetle upon a carefully packed bed or layer of chips, sometimes in the bark, but generally at the end of a branch gallery in the wood. In some species the ambrosia is grown only in certain brood chambers of peculiar construction. In others it is propagated in beds near the cradles of the larvæ. The excrement of the larvæ is used in some, and probably in all, of the species to form new beds or layers for the propagation of the fungus.

It is not alone, however, the excreta of the living beetles or their young that is required for the development of ambrosia; there must be present a certain amount of moisture or sap, and the sap in most species must be in a condition of fermentation. Certain ambrosia beetles seem not to need fermentation in the propagation of their fungus; their galleries are constructed in the sapwood of vigorous plants. The great majority of the species, however, attack the wood of such trees only as are moribund—trees in which the natural circulation of the sap has ceased and fermentation has begun. Some of the number are also able to produce their food fungus in wood which is saturated with a vinous or alcoholic ferment, and they attack wine and ale casks, perforating the staves with their galleries and causing serious loss by leakage.

The precarious conditions under which their food is produced limits the life of a colony of ambrosia eaters in most cases to a single generation.

Under favorable conditions and in large tree trunks, colonies may continue their excavations through two or three generations before the failure of the sap or changes of its condition put an end to their existence and force the adult beetles to seek new quarters

When their galleries are disturbed and opened to daylight, the adult beetles generally fall to eating their ambrosia as rapidly as possible. Like other social insects, they show their concern at the threatened loss of their most precious possession and try to save it, just as bees, when alarmed, fill themselves with honey.

As its honey is to the bee, so to the ambrosia-feeding beetle its food fungus is the material, the propagation and preservation of which is the chief concern of its life. Its solicitude concerning it is not surprising when one considers the herculean labors which it undergoes in the effort to produce it, the frequent failures, and the difficulties and uncertainties that at all times attend its preservation in the vegetative form, in which alone it can serve the insect as food.

THE LIFE HISTORY OF AMBROSIA BEETLES.

In the care which they give their young and in the methodical and complex provisions which they make for the welfare of the colony, these beetles display the characteristics of true social insects, such as are known among bees, wasps, ants, and the termites, but which have not hitherto been found to exist among any other representatives of the order Coleoptera.

These social instincts reach their highest development, apparently, in the genus Platypus. The species of this genus are readily known by their very long cylindrical bodies, their prominent heads, flattened in front, the flattened and spur-tipped joint of the front legs, and in the males the spine-like projections of the wing cases behind. They are powerful excavators, generally selecting the trunks of large trees and driving their galleries deep into the heartwood.

The female is frequently accompanied by several males, and as they are savage fighters fierce sexual contests take place, as a result of which the galleries are often strewn with the fragments of the vanquished. The projecting spines at the end of the wing cases are very effective weapons in these fights. With their aid a beetle attacked in the rear can make a good defense and frequently by a lucky stroke is able to dislocate the outstretched neck of his enemy.

The females produce from one hundred to two hundred elongate-oval pearly white eggs, which they deposit, in clusters of ten or twelve, loosely in the galleries.

The young require five or six weeks for their development. They wander freely about in the passages and feed in company upon the ambrosia which grows here and there upon the walls. The chitinous ridges upon the thoracic segment, together with the row of tubercles

upon the other segment, enable the larva to move as rapidly through the galleries as if it were possessed of well-formed legs. The mouth parts of the larva are also provided with strong cutting mandibles, but the inner jaws are not adapted to masticating hard food, such as particles of wood.

The older larvæ assist in excavating the galleries, but they do not eat or swallow the wood. The larvæ of all ages are surprisingly alert, active, and intelligent. They exhibit curiosity equally with the adults, and show evident regard for the eggs and very tender young, which are scattered at random through the passages, and might easily be destroyed by them in their movements. If thrown into a panic, the young larvæ scurry away with an undulating movement of their bodies, but the older larvæ will frequently stop at the nearest intersecting passageway to let the small fry pass, and show fight to cover their retreat.

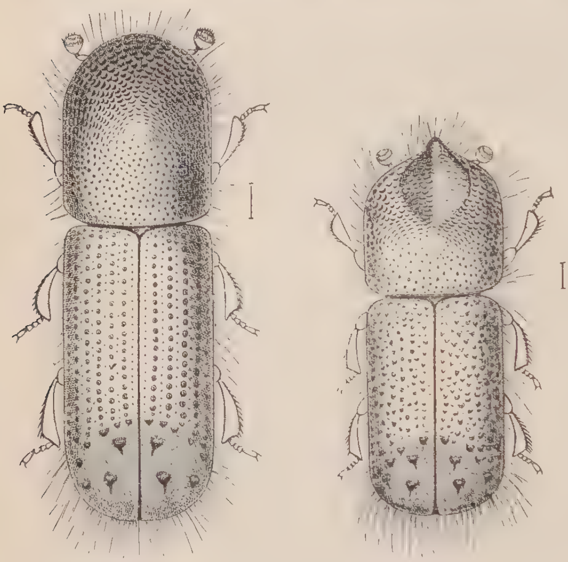

FIG. 103.—*Xyleborus celsus*, female and male.

When full grown the larva excavates a cell, or chamber, into which it retires to undergo its transformations. The pupa cells are cut parallel with the grain of the wood and generally occur in groups of eight to twelve along some of the deeper passages. The older portions of the galleries are blackened by the long-continued formation of the food fungus.

In the ambrosia of *Platypus compositus* the terminal cells are hemispherical, and are borne in clusters upon branching stems.

The species of Platypus do not attack trees in health. They are attracted only by the fermenting sap of dying or very badly injured trees. The death rattle is not more ominous of dissolution in animals than the presence of these beetles in standing timber. If the timber attacked by them is to be saved even for firewood, the sooner it is cut down and seasoned the better.

Another group of ambrosia beetle, the species of the genus Xyleborus, like Platypus, raise their young free in the galleries. *Xyleborus celsus* (fig. 103) and *X. xylographus* (fig. 104) illustrate in both sexes two of the more important members of this group, of which there are

numerous species in the United States. It will be noticed on reference to these figures that the males and females of each species are quite dissimilar. The males are smaller than the females; they are, moreover, without under wings, and the wing covers are solidly united so that they have not the power of flight and can not accompany the females when they go forth to found new colonies. Only one or two males are found in each colony.

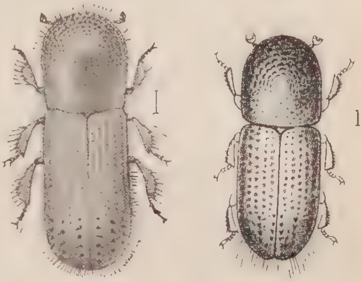

FIG. 104.—*Xyleborus xylographus*, female and male (original).

The males fertilize their brood sisters within the galleries, and by them a second generation may be started in the same tree. But usually the seasoning of the wood and the threatening failure of the food fungus warn the young females to depart and seek fresher tree trunks in which to found new colonies.

The swarming of the females leaves the abandoned males in sad plight. Since they are unable to consume the rapidly ripening ambrosia, they must also wander forth, although wingless and weak in organization, or perish by suffocation. They therefore frequently assemble in certain galleries to form bachelor colonies, where by their combined numbers they are able for a time to prolong their existence. They are found sometimes to the number of fifty or sixty, packed one behind the other in a single gallery.

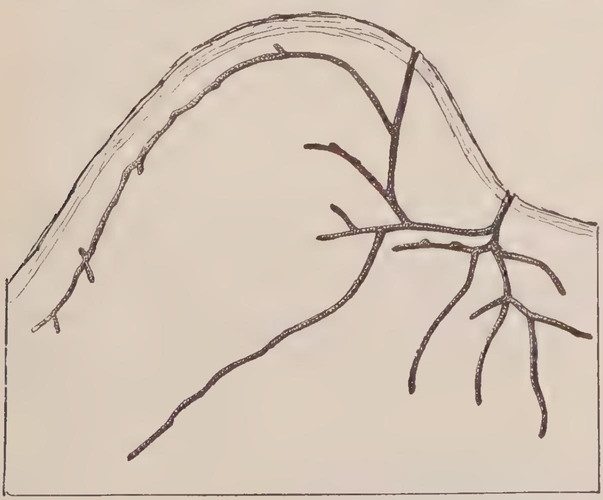

FIG. 105.—Gallery of *Xyleborus pubescens* in orange.

The females alone excavate the domiciles, which consist either of branching galleries, as in the gallery of *Xyleborus pubescens* (fig. 105), or of a broad but thin and leaf-shaped chamber at the end of one of several entrance ways, as shown by the gallery of *X. xylographus* (fig. 106). In the former the mother beetle constructs several branches leading off from the main gallery, and in each of these she starts a fungus bed and deposits a cluster of five or six eggs. The young of these little broods, hatching at about the same time, keep

together during their growth, and at maturity undergo their transformations to pupa and to the perfect beetle without constructing any cell or protective covering, simply extending themselves in single file along the gallery in which they found themselves at birth.

The species which construct a communal brood chamber like that shown in fig. 106 (gallery of *X. xylographus*) likewise form no separate cells or coverings in transforming to pupa, but as in the nests of ants, the eggs, larvæ, and adults, numbering sometimes several hundreds of individuals, occupy indiscriminately and without interference with each other the general apartment, upon the walls of which fresh crops of the food fungus are constantly propagated for the nourishment in common of young and old.

The ambrosia fungi propagated by the various species of Xyleborus are always of the stalked forms, bearing single spore cells. A few of these fungi have been examined and one of them is illustrated by the ambrosia of *X. celsus* (fig. 101).

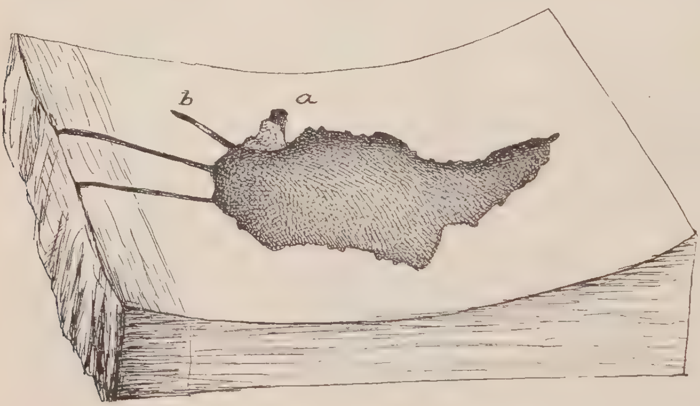

FIG. 106.—Gallery of *Xyleborus xylographus*.

The material upon which these fungi are grown consists, as has been stated, mainly of the excrement of the beetles or their young, mingled with chips of wood which have passed through the intestines of the insects and have become stained with a color which is characteristic in each species. The fungus bed in the species represented by the ambrosia of *X. celsus* (fig. 101) is a deep brown; that of the ambrosia of *X. xylographus* is yellow. The walls of the brood chamber covered with the latter often appear to be coated with a powder resembling sublimed sulphur.

In the two groups or genera of ambrosia beetles which we have hitherto considered the young live socially with their elders. In the larval stage, although deprived of legs, their bodies are provided with various devices which enable them to move freely about the galleries. Another large series of ambrosia-eating timber beetles pursue an entirely different system of rearing their young. The larvæ are not only legless, but destitute as well of any locomotive contrivances, and,

like the grubs of bees and wasps, are separately inclosed in cells, which they never leave until they become adult.

In all the cradle-making ambrosia beetles the sexes are alike. The perfect males are winged and accompany the females in their flight. One or two males usually assist each female in forming a new colony.

Their galleries, one of which is shown by fig. 107 (galleries of *Xyloterus retusus*), extend rather deeply into the wood, with the branches mostly in a horizontal plane.

The mother beetle deposits her eggs singly in circular pits, which she excavates in the gallery in two opposite series—one up and one down—parallel with the grain of the wood. The eggs are loosely packed in the pits with chips and material taken from the fungus bed which she has previously prepared in the vicinity and upon which the ambrosia has begun to grow.

The young larvæ as soon as they hatch eat the fungus from these chips and eject the refuse from their cradle. At first they lie curled up in the pit made by the mother, but as they grow larger, with their own jaws, they deepen their cradles, until at full growth the latter slightly exceed the length of the larva when fully extended. The larvæ swallow the wood which they excavate, but do not digest it.

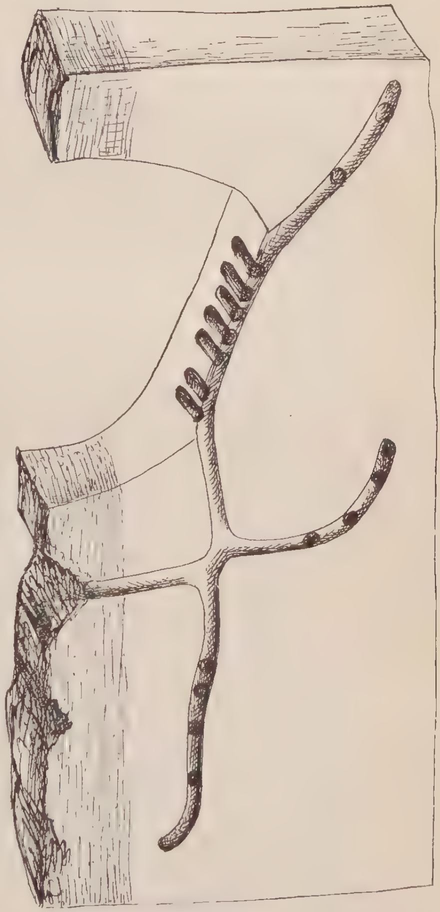

FIG. 107.—Gallery of *Xyloterus retusus* in aspen.

INJURIES CAUSED BY AMBROSIA BEETLES.

As a rule, populous colonies of these beetles and borings so numerous and extensive as to inflict serious injuries are found only in trees which before the attack began were sick unto death with maladies for which the timber beetles are in no wise responsible. The few species which enter the sapwood of vigorous trees do not form large colonies, and the effect upon the health of the tree is not appreciable. One or two species, it is true, have the habit of sapping the life of twigs or small branches with an encircling burrow, and a species of

Corthylus does considerable injury in this way to young trees and to shrubbery in the forests.

The defects in wood caused by the galleries and the stains left by ambrosia beetles probably entail more serious losses than their direct attacks upon living trees.

The majority of the species confine their depredations to the sapwood of recently felled or dying trees. They therefore affect injuriously the least valuable portion of the wood. On the other hand, some of the larger and stronger species are capable of entirely destroying for any useful purpose except for fuel the timber of the largest trees. Their borings penetrate the heartwood in every direction and riddle it with holes.

Occasional black holes and stains left by these beetles in the heartwood of timber otherwise sound reduce its grade and its value in the market, and render it unfit for use where the full strength of the material is required.

The damage to timber intended for use as cask headings, staves, shingles, and the like, is very serious. Cask makers frequently repair the damage, when not too extensive, by closing the holes with wooden pins. The holes made by certain species of timber beetles can not be plugged, but in most cases, owing to the uniform system followed by each species in constructing its galleries, a particular method of sawing is capable of reducing the damage to a minimum and of effecting a very considerable saving of material.

REMEDIES.

From what has been said of the nature of the food of these beetles, it is evident that any method by which the entrance to their galleries in the bark can be closed will effectually put an end to the progress of their colonies. Perhaps the best means of accomplishing this is by coating the trunks with dendroline or raupenleim. A light brushing or spraying of the bark with creosote or kerosene will sometimes accomplish the same result, especially at the beginning of an attack; but this can not be depended upon to permanently protect the trees. Valuable fruit trees which have suffered injury from fire or frost can not always be protected from attacks of the borers by coating the bark, because of the risk of injury to the buds which must be allowed to grow upon the trunks. In such cases, if ambrosia beetles enter the wood their holes must be plugged. An excellent method is to insert an iron wire as far as it will go, cut it off, and leave the piece in the hole. The inhabitants of colonies thus imprisoned are unable to extend their borings and inevitably perish.

CARE OF DAIRY UTENSILS.

By R. A. Pearson,

Assistant Chief, Dairy Division, Bureau of Animal Industry, U. S. Department of Agriculture.

CLEANLINESS UNDERLIES ALL SUCCESSFUL WORK IN DAIRYING.

Makers of first-class butter and cheese and the best dairy farmers and milk dealers in general attach the greatest importance to cleanliness. They know that it is as necessary to have clean utensils in the dairy as it is to have clean milk, and that the largest profits are secured only when cleanliness is required in every branch of the work. Milk may be produced in sanitary stables by well-fed and well-cared-for cows and drawn in a cleanly manner. These conditions contribute much toward superior dairy products; but the good effects of such care are wasted unless it is extended to the utensils. When this fact is fully appreciated and proper attention is given to cleaning and caring for utensils, the quality of dairy products will be improved.

A butter maker whose product was described as of very superior flavor, being asked the secret process by which such fine butter was made, replied, "I have no secret beyond this: I am always very particular about keeping thoroughly clean every vessel with which the milk and cream come in contact." This is one of the chief things that enable one milk dealer to charge 10 cents a quart while others sell for 6 cents, or one butter maker to get 30 cents a pound for his butter when others receive but 20 cents.

It is now well known that changes of milk are dependent upon bacteria, and the rapidity with which germs multiply in milk has been frequently referred to in publications of the Department. Bacteria are especially numerous in and around a dairy, and they get into the milk in many ways. The difficulty is to keep them out; this requires the milk to be handled in such a way that no contamination can take place. Theoretically, this is easy, but in practice it is impossible. It is possible, however, to greatly reduce the sources of contamination, one of the most common and inexcusable of which is improperly cleaned milk vessels.

Thousands of bacteria may be concealed in a crevice so small that it can hardly be seen, and if these get into the milk they may increase more than one thousandfold within twenty-four hours. A little milk left under the rim or about the "ears" of a tin pail harbors a much larger number of germs, and their deleterious effect is correspondingly great. Improperly cleaned churns contain myriads of bacteria,

which impart a peculiarly disagreeable flavor to each churning. Cheese makers are frequently troubled by tainted milk or floating curds, and a poor quality of cheese results. These conditions are often accounted for by carelessness in cleaning utensils either on the farm or in the factory. Many city milk dealers have had like experiences. Their trouble is partly due to failure in cooling milk sufficiently to retard bacterial growth, but it is also partly due to not thoroughly cleaning the pails and cans. Some milk buyers insert special clauses in their contracts with farmers relating to cleanliness.

The losses from neglect of the matter of cleaning utensils exceed those caused by the addition of water or the abstraction of cream. Dirt in a solid or sedimentary form can easily be removed from milk, but its bad effects can not. Special strainers, filters, or the separator will make milk appear clean, but none of them can take out bacteria or the taints caused by them.

A good water supply is essential to cleanliness. Clear spring water or that from a deep well is usually the best. Water from cisterns, shallow wells, or streams is sometimes satisfactory, but if it is liable to be contaminated by surface drainage it is not safe. It may contain innumerable forms of vegetable life and bacteria, which are capable of causing peculiar behavior in the dairy. There is also a chance of some disease-producing germs gaining entrance to the dairy through impure water.

SELECTION OF DAIRY UTENSILS.

In purchasing dairy utensils care should be taken to get those which can easily be cleaned. Other things being equal, the more accessible the inside surface of an article for dairy use the more valuable it is. Any having corners or parts which can not be easily reached with water and a brush or cloth should be avoided. A vessel should be discarded if it has sharp, angular corners, unless they are absolutely necessary, for they require too much attention. All dairy utensils should be of hard material and have smooth surfaces. Wooden pails should never be used for holding milk, as in the surface of the wood there are numberless small pores and fissures. Each one holds a minute quantity of milk, and when the pail is emptied the water of the milk quickly evaporates and leaves a residue in the small recesses. It is impossible to perfectly clean these, and this is especially true when the small cells connect by little narrow openings with others farther back in the wood.

Metal is the best material for milk vessels, and tinware is commonly used. It pays to have a good quality of tin which will not soon wear off, leaving the iron bare. Some other common metals are occasionally used, but are objectionable on account of their liability to corrode. The joints and rims should be made smooth and the cracks entirely filled with solder. Cheap tinware is put together so

carelessly that the joints are often rough and uneven, and little projecting points of solder make it difficult to move the cleaning cloth along the seam. Pails and other circular tin vessels should have but one seam on the sides; better ones are made without a seam.

It is important to keep the outside of utensils clean. In order to facilitate the work, the outer surface should be so finished that every part can easily be reached by water and cloth. The outside of tinware should be finished as smoothly as the inside, and all wood apparatus should be carefully finished on the outside, being made smooth and having as few projecting nuts, rods, and braces as possible.

Glass is sometimes used for holding milk. It was especially recommended twenty-five years ago because of its "nonconductivity of lightning." It is very smooth, easily cleaned, imparts no taste to the milk, and shows dirt plainly. On the other hand, it is expensive, brittle, and heavy, so that its use for larger vessels is limited. The same facts apply in the main to glazed earthenware.

Churns should be made of a close-grained wood which will not impart taste or odor to the butter. Special care should be taken to have the openings so large that the work of cleaning can be easily done.

Milk pumps and all other apparatus through which milk passes should be as simply constructed as possible, and in such a way that they may be easily taken apart to be cleaned.

It is not economy to keep old, dilapidated milk vessels, churns, or utensils of any kind. Cans and pails with double bottoms or patches on the sides, having many dents, and large surfaces of bare iron from which the tin has been worn, and churns with sides almost rotten, are responsible for much loss. Such articles are not found in the best dairies or factories.

CLEANING.

Almost any utensil can be cleaned by the persistent use of the scrubbing brush, hot water, and sal soda. The labor may be considerably lightened, however, by observing some of the suggestions which follow. Every step in the operation of cleaning is important, and it can hardly be said that any one is more so than another; each requires strict attention, even to the minutest details.

Clean promptly.—Fresh milk is easily removed from a surface, but if it is allowed to dry on and become sour, or perhaps decayed, hard work is required to get it off. Under the best conditions it is difficult enough to clean dairy utensils, but when they are allowed to become dry before cleaning the labor is greatly increased. If it is impossible to fully clean a milk vessel soon after use, it should at least be filled with water, and then it can be easily cleaned later.

Every part of an article that comes in contact with milk should be cleaned with a brush or be in plain view when cleaned.—A cream separator can not be properly cleansed by running water through it,

and such an effort is rarely made, but frequently the apparatus is not taken wholly apart, as it should be. By means of long-handled or very small brushes, every part should be reached, special care being taken to use the brush about all seams and joints. Much trouble is sometimes experienced with pumps used for milk; they should be taken apart to be cleaned every day they are used. The outside of utensils should not be neglected. Anyone who cleans glass jars appreciates this matter.

Tinware.—Articles made of a good quality of tin and not battered or badly worn are easily cleaned.

Milk should always be rinsed out of vessels before they are scalded. If this is not done, the albumen of the milk will be coagulated by the heat and adhere to the sides, making its removal difficult. It is important, therefore, not to have the first wash water too hot. Cold water is sometimes recommended, but this is not necessary, as it may be quite warm without changing the condition of the albumen. The best practice is to rinse the vessels with cold or warm water, then wash in hot water with the aid of some cleaning preparation, then rinse carefully and enough to remove all soap, sal soda, or other cleaning material, and finally sterilize in a steam chest, exposing them to live steam about three minutes. The methods generally used in washing milk vessels are very imperfect. The vessels are often carelessly rinsed with cold water, then one is filled with hot water and cleaned with a cloth, the same water being made to serve for other vessels successively, being turned from one to another, and by the time the last is reached the water is no longer hot and is decidedly milky. When water is not hot, the grease is not removed, but simply smeared over the tin. Two wash sinks should be close together, one for the general cleaning and the other containing clean hot water in which each article is rinsed as soon as it has been washed. Most utensils easily dry after being steamed, but if they do not they may be put in a drying room or wiped with a clean cloth. They should be placed in pure air, and in sunshine if convenient, though this is not necessary if well cleaned and thoroughly sterilized.

Cans and pails for carrying milk should be used for no other purpose. It is well to have the cans cleaned and sterilized at the factory, where there are special facilities for this work. In many cases this is done for the patrons free, while in others a small charge is made. Milk cans and pails should never be allowed to stand in the stable before they are needed there for use. Myriads of bacteria are constantly floating about in the air of the stable, especially when dust is raised by feeding, and milk utensils should not be unnecessarily exposed to them. They should be kept in a clean place, with covers off, surrounded by pure air, and should always be rinsed with clean water just before milking time.

Milk coolers are apt to be badly neglected, often because they are

used in or near the stable and it is not convenient to take them to the dairy house or kitchen to be cleaned. So they are simply rinsed off with cold water and allowed to remain where they are used. In cases where they are cared for in this way their effect on the milk is worse than if they were not used at all.

The heavier metal utensils and their parts are cleaned in the same way as tinware. The cleaning of a separator bowl is aided if it has been flushed out with warm water instead of skim milk.

Glass.—The directions for cleaning tinware apply almost equally well to articles made of glass, porcelain, and earthenware. In most factories and dairies there are few such articles to be cleaned, although glass or porcelain may be used for milk-setting vessels, and earthenware is used for milk or cream receptacles and for butter jars. The bottles for the Babcock test are frequently the only glassware; but these are sometimes so neglected that accurate results with them are impossible. They should be cleaned with hot water immediately after use; a few drops of sulphuric acid or strong alkali will usually aid in removing matter adhering to the bottoms of the bottles, and their necks may be cleaned with a slender brush made for the purpose. A great deal of milk is now placed on the market in glass jars. These are easily cleaned, as dirt on the glass is readily seen. They should be allowed to remain in warm water for a short time and then treated as above described for tinware. If they have attached tops, special care should be given to these and the arrangement for holding them on. These are the parts most liable to hold foreign matter. The temperature of glass must not be changed too suddenly; much breakage often results from neglect in this particular.

Wooden articles.—Churns, butter workers, and other utensils made of wood and used for handling butter should have any small particles of butter loosely adhering to them removed with cold water immediately after use. They may then be scalded with the first wash water if no albumen is present, which is usually the case on the butter worker and smaller wooden articles and on the churn when the butter has been washed in it. No article in the establishment is more liable to be slighted in cleaning than the churn. A few revolutions of the churn with some boiling water in it and a little of some cleaning material should be followed by a rinsing with hot water. It should then be carefully inspected, and, if found necessary, again thoroughly cleaned and rinsed. The inside of the churn should be kept smooth. For this reason rough materials for cleaning are objectionable, as is also the use of large pieces of ice for cooling the cream in the churn.

All wooden utensils should be scalded, or, better, steamed, after being washed. This treatment is especially necessary for the churn. Hot steam penetrates every corner and joint and gets into the wood enough to melt the fat that has been soaked up. It requires little time to attach a hose to the buttermilk outlet and steam the churn

after washing it. When this is being done, the cover must not be fastened down, or some damage may result from too great steam pressure. Care should be taken not to expose the churn too long to the steam, as this might cause it to shrink and allow the joints to loosen; and care should also be taken to loosen the nuts on the binding rods of a new churn to allow the wood to swell. After cleaning and sterilizing wooden utensils, they should be inverted in a clean place where they can drain and be dried by fresh air. It is well to put them in the sun for a short time, but not long enough to crack.

Before the butter printer, ladles, and other articles made from wood are used they should be soaked in hot water and rinsed in cold water. The wood is caused to swell by the first treatment, thus closing the pores, and the surface is chilled by the cold water so that the butter fat coming in contact with it is made hard and does not stick to it.

Iron.—The scales, testing machine, pumps, separator frame, and other similar articles should be regularly cleaned. Hot water and a brush are usually sufficient to keep these in good condition. After they have been cleaned, they should be wiped dry with cloths or waste. A coat of black asphalt varnish on iron from which the paint or varnish has been worn prevents rusting, improves the appearance, and lightens the labor of cleaning.

Cloths, sponges, and rubber rings should be thoroughly rinsed in warm water and then cleaned in hot water and scalded in boiling water or steamed.

The cleaning of dairy utensils is aided by the use of mechanical appliances and some materials which are added to the water. These are discussed below.

APPLIANCES FOR CLEANING.

Many patent mechanical devices for cleaning dairy utensils have been put on the market, but their general adoption is slow. Bottle-washing machines, consisting of rapidly revolving brushes, are in operation in some large milk-shipping stations, while in others all the cleaning is done by hand. An arrangement that has been recommended for cleaning bottles consists of a piece of rubber hose split into fingers and rapidly revolved in the bottle. Where much cleaning of cans has to be done, large revolving cylinders covered with brushes are sometimes used. Light power is required for these brush machines. Hand or foot power is sometimes used, steam and small electric motors are frequently employed, and water power is successfully applied. Patent appliances are advertised for cleaning some dairy machinery without taking it apart. It is doubtless a saving of time and labor to use such aids, but they can not be depended upon for perfect work.

A stiff brush is one of the best cleaners known. Brushes are made in all shapes and sizes—very small ones for cleaning the necks of test bottles; long, slender ones with flexible handles for cleaning straight or curved tubes; round brushes on the end of a stick or

wire handle about 10 inches long for bottles; various-shaped flat ones, similar to the ordinary scrubbing brush, for large surfaces, and brushes of roots or tough twigs for rough surfaces and hard scrubbing. The ordinary brush with an extended handle is convenient for cleaning cans, as it makes it unnecessary to put the hand into the water, which may be used very hot.

A coarse cloth answers the purpose of a brush, but special care must be taken to clean it after use. A sponge should not be used in the dairy, as few persons will take the time necessary to keep it clean.

Every factory and creamery should include in its equipment suitable wash sinks and a steam tank. Two wash sinks are usual, or a long one divided into two parts—one for washing and the other for rinsing. They are in the form of a wooden box, standing high enough for convenience in use, and sometimes lined with tin or galvanized iron. A shelf may be attached to one end, inclined toward the sink, for use in draining the utensils. Each sink should be large enough to hold a 10-gallon milk can and so deep that 8 or 10 inches of water will not easily splash over the sides. It should be connected with the drain so that water will not run over the floor, as it does in many factories. The sinks should be connected by pipes with the water supply in order that cold water can be had at will, and if steam is available it should be brought direct from the boiler to the sinks; thus water can be quickly and easily heated. Steam admitted directly into the water from the end of a pipe makes a loud noise, but this can be avoided by an attachment to the end of the pipe which diffuses the steam and renders it noiseless. When water is used for sterilizing, it must be kept very hot, and some provision should be made to constantly maintain the proper temperature. This is easily done by injecting steam into the water, but if steam is not available a special heater may be used, so arranged that hot water from the boiler is continually entering the sinks, fresh water being supplied to the boiler, and an overflow placed in the sink to carry off as much as is added, or the water is caused to flow from the sink to the boiler, where it is reheated and returned. In some cases the water is kept hot by being used while it is over the stove. Each of these latter methods is objectionable on account of the loss of heat, or of the return of dirty water to the boiler, or of its inconvenience, and steam is much preferred.

The direct use of steam for sterilizing is very common. In many factories and dairy houses there is, adjoining the wash sink, a table, in the center of which is a steam jet, and when cans are washed they are inverted over this jet and steamed for a few moments. This method of steaming answers the purpose fairly well in certain cases, as when a large number of cans are washed and a special room is provided for the purpose, or the steam jet is under a hood which conducts the escaped steam to a pipe leading out of the building. Special care

should be taken to make the exposure long enough, but one using this system is liable to make the time too short. Another objection to it is that the steam does not come in direct contact with the outside as well as the inside of the cans. More perfect work is accomplished by a steam chest, in which the smaller utensils, such as cans, pails, dippers, glass jars, etc., may be placed and entirely surrounded with steam as long as desired. A galvanized iron chest from 3 to 5 feet each dimension is large enough to hold the utensils, except vats and machinery, ordinarily used in a creamery or cheese factory. When many cans are to be cleaned, the chest should be large enough to hold a dozen or more at a time. All joints must be made as close as possible. The doors should be large, so that articles may be easily put into or removed from the chest. At the top of the steamer there should be an escape pipe 2 or 3 inches in diameter and passing out of doors. The flow of steam through this may be controlled by a valve, and each time the steam is turned off a few moments should be given to allow most of it to escape from the chest through this large pipe before the door is opened. If this is not done, the operator may be severely scalded by opening the door while the steam is still under pressure. Steam should be admitted at the bottom, and the bottom should have enough incline to cause all water formed by condensation to run off through a trapped pipe leading to a drain. About 6 inches above the bottom a movable false bottom of strong wire netting or iron framework may be placed, on which the articles are put in an inverted position. If more room is required and the articles are small, shelves similar to the movable bottom may be used.

Several different materials are employed for constructing steam chests. Wood gives good satisfaction when the chest is used often. It should be firmly bound to prevent bad results from warping. Galvanized iron is a common material, and copper is sometimes used. If a metal is used, the door should be double to make it rigid.

A convenient method of steaming utensils on a large scale is to have, instead of a tank, a steam closet, the floor of which is on a level with the main floor of the building. A light truck with skeleton bottom and sides may be loaded with articles from the wash tanks and quickly rolled into the closet, steamed, and the utensils taken to their proper places with very little handling. Such a saving of work amounts to a great deal in a large factory.

Steaming is often omitted for the want of a suitable chest or closet. If no better method is available, an ordinary wooden box with a tight-fitting cover may be easily and cheaply arranged.

Every dairy utensil should be frequently sterilized, and nothing is better for this purpose than superheated steam direct from the boiler. Not an inconsiderable amount of steam is needed for this purpose and for heating water and, when necessary, the building, and these facts should be borne in mind when a boiler is purchased, care being

taken to have its capacity greater than required by the engine, so that steam can be taken at any time for these other purposes. But, if desired, small boilers may be obtained for furnishing steam for heating water and sterilizing only, their cost being $25 or upward, according to size. Such a boiler is especially recommended for any factory or large dairy not already equipped with steam.

MATERIALS FOR CLEANING.

Sal soda, known as washing or laundry soda, is widely used for cleaning dairy utensils and is one of the best and cheapest cleaning agents known. It may be safely used in the dairy, as it is neither poisonous nor corrosive. The proportion of sal soda to water for cleaning purposes is small, and can be quickly learned by experience. The substance is objected to by some people because it blackens tin, but this does not occur unless too much is used and the utensils are not well rinsed after its use.

The value of various alkalies for cleaning has long been known. Our grandmothers knew that wood-ash lye, or soft soap made from strong lye, was an effective agent in cleaning a bad-smelling milk can or churn, and lye (generally in the commercial form, concentrated, in cans) is now sometimes used in creameries, especially in hot weather, for the same purpose. The objection to such a strong alkali as lye (caustic soda or caustic potash) is its effect on animal tissues, which it readily dissolves, or "eats," causing the skin of the hand to corrode and crack. It will also dissolve the sap and resin in the sides of a churn and cause the wood to splinter. Soda lye is cheaper than potash lye, and is the form of strong alkali commonly used.

Numerous preparations in the form of soaps and soap powders are made for use in dairies and factories. They are usually a strongly alkaline soap ground into small bits, or a mixture of powdered soap and sodium carbonate (sal soda). Oils and sodium carbonate are the chief materials used in the manufacture of these cleansers. Mineral matter is sometimes employed for adulteration. It is claimed that cheap fats and resin are not much used. Special cleansers cost three or four times as much as plain sal soda, but many operators prefer them because of their convenient form for use and their greater cleansing power, reasons for this being the large amount of water held by the soda and its slowness in going into solution. Another reason is undoubtedly the greater cost of the preparations, which leads to more care in their use, and hence better results. Sal soda is excellent for removing fat or grease, but soap may be better with other forms of dirt.

The ordinary laundry soaps are made with cheap fats, and contain much resin and frequently an excess of alkali. They are quite liable to adhere to the utensils sufficiently to impart a disagreeable taste and odor to the milk. If low-grade materials were used for the powders, they would be as objectionable as cheap soap.

Dairy utensils frequently become dull and require to be scoured. One of the commonest materials used for scouring is salt; it is cheap, does good work, leaves no bad flavor, and it should be used even more than it is. Sand is sometimes used, but it must be very fine or it will scratch the utensils. Some soaps have fine sand mixed with them, making an excellent combination for scouring.

STERILIZATION.

About a century ago it was thought that milk vessels were cleaned to free them from acid, and one of the old dairy writers (Cramp, 1809) advised boiling the pans from two to three hours to remove the acid and thus prevent the butter from being "hot and bitter" Such treatment doubtless gave the desired results, because it not only removed any acid that might be present, but it removed the cause of the acid, which was bacteria.

By sterilization of a utensil is meant the destruction of the life of all germs which may be on its outer or inner surface. The object of sterilization usually is to kill the bacteria that cause milk to sour (lactic acid bacteria), and which may not be removed in the ordinary washing. But sterilization of utensils is very important for other reasons; it destroys germs causing other than the lactic acid fermentations and those causing peculiar changes in milk, as well as pathogenic or disease-producing germs. The temperature of the wash water generally used is not high enough to kill bacteria, and many of them remain on the article after it has passed through the water, ready to plant themselves in the next milk with which they come in contact. It has been shown that when all these are destroyed the number of bacteria in milk is very much lessened. For this reason sterilized vessels are recommended instead of unsterilized ones cleaned in the usual way. Experiments conducted in the Department of Agriculture prove that milk in well-cleaned vessels may keep sweet twenty-four hours longer than that in worn tin cans, washed as thoroughly as is done in many dairies, but not sterilized.

In practical work, articles are not rendered absolutely sterile. This would require a long exposure to steam under pressure and necessitate an especially strong chest. The methods generally followed are referred to elsewhere in this article. Care should be taken to make the exposure long enough to kill all active germs that may be present. Different species of bacteria are killed at different temperatures; some species have great powers of resistance, and spores usually withstand a high temperature. It is fortunate that a comparatively low temperature is fatal to most of the growing forms and to pathogenic bacteria. The lower the temperature to which bacteria are exposed, the longer must be the exposure. The temperature of steam under a pressure of 20 pounds or more, as it is in the boiler, is above that of boiling water, and if steam under this pressure is conducted to

a small chest and there is little condensation, a usually safe rule is to allow the steam to enter for three minutes. In some cases, where every precaution against contamination is taken, the time is extended to fifteen or twenty minutes. Often there is little pressure and much condensation in the chest, especially in one made of tin or galvanized iron and situated in a cold room; in such case the exposure should be long.

Another advantage of steaming utensils is that they are heated so hot that they dry quickly and more perfectly than when wiped, and this tiresome work is avoided.

Hot water is used for sterilizing in some dairies and factories, and is efficient so long as it is kept at the boiling temperature, but without a thermometer one may be easily deceived and think that water is boiling hot when it is far from it. Few persons can work in water at 130° F., and it is considered very hot at 150° F. A little rinsing water at this temperature may be of use to remove wash water, but it does little in the way of killing germs which have escaped the brush. Few persons can tell when water is near 212° F., and it is doubtful if it is often above 200° F. when used for scalding. Steaming water is not necessarily hot; cold water may "steam" under certain conditions. Different methods of heating water have been referred to in this article.

Germs are killed much more easily when in a moist medium than when they are dry. For this reason a higher degree of temperature is required when hot air is used for sterilizing than when steam is used. In hot air a temperature of over 300° F. and an exposure of at least an hour is necessary to complete sterilization. A chest for hot-air sterilizing is more expensive than the same for steam, and it requires more heat, meaning extra expense and much discomfort in warm weather. For these reasons hot-air sterilization of dairy utensils is rarely practiced.

The use of chemical disinfectants for sterilizing dairy utensils is out of the question, as they are solid materials or fluids or gases having objectionable properties and are frequently poisonous.

BUILDINGS.

A subject so close to the one discussed above that it is difficult to separate them is the cleanliness of buildings in which dairy operations are conducted. Clean churns, cheese vats, cans, strainers, dippers, brushes, and cloths are not usually found in dirty factories or dairies. Some factories reek with filth, but fortunately the number of these is very limited and their output small. Their disagreeable odor, caused by decaying milk, rotting wood, foul drains, molds, and general filth, can not be gotten rid of by scrubbing and a coat of paint or whitewash. Usually the only satisfactory way to deal with such places is to burn them.

When a building is to be constructed for creamery purposes, an elevated, well-drained location, or one that will always be dry, should be selected, and the best possible drainage must be provided; if this is not done, a clean factory is out of the question. If the matter of drainage is neglected, a sour, musty odor will soon penetrate the entire building and make the manufacture of finely flavored products an impossibility. No bad smell should be tolerated inside of or about a creamery building, and the building should be situated where no pronounced odor can reach it, whether from stables, manufacturing plants, or natural causes. It is not the purpose here to say how a building should be planned, but it may be stated that convenience and comfort conduce to cleanliness. There should be plenty of room and places for everything, care being taken to have shelves or hooks or drawers for the small utensils. Ventilation is essential to good air, and provision should be made whereby the air may be changed as often as necessary.

A room in which dairy operations are conducted should be used for no other purpose. Cream is frequently ripened and butter made in a pantry or where cooking is taking place or in a foul-smelling cellar, and it is not understood why the flavor and keeping qualities are bad. Dairy products absorb odors from the atmosphere very readily, and if cream or butter is exposed to the air of a close larder where various kinds of food are kept, or to the kitchen or laundry air which smells strongly of steaming vegetables, suds, or smoke, or the musty air of a cellar, an unpleasant flavor in the butter may be expected.

As long as an article is kept dry, the development of bacteria is restricted, but as soon as it becomes damp one of the necessary conditions for growth is provided, dampness being to them as essential as warmth. It is important, therefore, to keep the factory and dairy dry. An excess of water is almost as bad as a deficiency; constant splashing makes the floor wet and sloppy. When it is possible, the wash sinks and steam chest should be in a room separated from the main working room of the building. Dryness is also promoted by good ventilation. Cracks in which dirt has accumulated contain an incredible number of bacteria of many species, and when this dirt is moist they multiply with the greatest rapidity. When a building is constructed, care should be taken to avoid cracks, corners, and crevices. Cement is generally recommended as the best material for the floor, and when it is on a good foundation (so that it will not crack) and its surface is smooth thorough satisfaction is given. Flagstones are not uncommon. When they are used, the joints should be filled with cement. Tile floors and walls are found in a few dairies, but are not extensively used on account of their high cost. Walls are occasionally constructed of hollow brick or tile, which aid in keeping out the heat. Table tops and shelves are sometimes made of slate or marble, either of which is very good so long as it does not crack. Light is

almost essential to cleanliness; sunlight is a good disinfectant and at times it should be allowed to pour into the building and shine unrestricted on the utensils. A building should be so well lighted that dirt in any part can be readily seen; a dark corner is not likely to be as well cleaned as a light one. It is a great mistake to cover the inside of a building with dark paint, so that fly specks and other dirt will not show. On the contrary, light-colored paint should be used, not only for better general effect, but with the object of making all uncleanliness plainly seen.

In the care of a building the work may be greatly lightened by giving attention to some small matters too often entirely overlooked. Many factories are surrounded with ashes, cinders, or mud, sticky at times, and everyone entering carries in some of this dirt. A few loads of gravel outside of each door or, better, a flag or board walk, would reduce this nuisance. Persons wearing dirty work clothes should not be admitted. Farm hands frequently have full liberty to go where they please in the creamery or factory, and they carry legions of bacteria to places which should be kept scrupulously clean. On dairy farms the necessity of stable employees entering the dairy house to deliver the milk may be avoided by the use of a conduit which passes through a sleeve in the wall. This has a receiver on the outer end into which the milk is poured and conducts it to a cooler or milk vat within. Some of the black dirt can be avoided by occasionally sprinkling the pile of coal from which dust rises each time it is stirred. And if the water supply is abundant it is well to sprinkle the road near the building, both to settle the dust and to cool the air. Screens on the doors and windows will contribute a great deal toward cleanliness by shutting out flies and other insects.

The building should be cleaned regularly, special care being taken to remove from the walls spots of mold and any dirt that may contain colonies of bacteria. As much care should be taken to keep the floor dry as is used in the kitchen, where, if cleaning is needed in a certain place, a little water is used and immediately wiped up. The floor should be thoroughly cleaned daily after the work is completed, first scrubbed with warm water and then scalded to partly sterilize it and to make it dry quickly. If it is uneven, the water should be removed, else little pools remain and keep the place damp until they have evaporated. A convenient instrument for removing the water is a mop made by attaching a strip of rubber to a piece of wood 4 inches wide and 18 inches long, so that the rubber projects about an inch beyond the side; at the center of the wood a handle is inserted. With this appliance almost all the water can be removed from a flat surface.

The wash sinks and vats should be connected with the drain. This prevents unnecessary slopping and also makes it possible to flush the drain frequently. If this flushing with water, which is occasionally boiled before use, does not keep it clean, copperas should be placed

in the drain as a disinfectant. Tanks of cold water are frequently used for storing milk and cream. The water should be changed often enough to prevent it from becoming foul from milk or from dirt from the outsides of the cans.

One of the greatest nuisances about many factories is the skim-milk, or whey, tank. It would not be necessary to remove this several rods to avoid its stench if it were properly cared for. Some tanks are not cleaned during the entire summer, some are cleaned once a week, while some careful operators clean their tanks daily. The tank should be easily accessible, and care should be taken to have the by-product which it contains exhausted each day in order that the tank may be thoroughly cleaned. If this is impracticable, two tanks may be employed, the larger one to be drained into the smaller after most of its contents have been taken away by the patrons; it may then be cleaned, and the smaller one should be cleaned as soon as possible after it is emptied the following day. In a creamery, one tank may be used for sweet skim milk and another for buttermilk, and these may be cleaned on alternate days, anything remaining in the one to be cleaned being run into the other. The sweet skim milk is always put into the clean tank. If the cans in which milk is delivered must be used for returning the by-product, the latter plan is by far the better, because it avoids the necessity of putting a very sour fluid into vessels which should be kept sweet. The agents usually employed in cleaning these tanks are a brush, scalding water, and washing soda, or lye. They should first be rinsed and partially cleaned with warm water.

Floors, ceilings, walls, utensils, and operators are usually alike, so far as cleanliness is concerned. Butter and cheese makers should have pride in their own appearance; they should be clean and neat. Washable white cloth is the best material for dairy work clothes, which should be changed often. When all the work of a factory, including the care of the fires, is performed by one individual, it is almost impossible to keep clothes clean. It may be done, however, and will be found much easier, if a little time is given each day to keeping the boiler room clean. It is important to have clean hands. In some factories where food materials are prepared the employees' hands are examined by the superintendent before they are allowed to go to work. Operators should be more careful in handling milk and its products, and should not have the habit of dipping the fingers or hand into milk, cream, or butter when not necessary. No person who has been working in a stable, barn, or field should work in the dairy or factory until he has washed, and changed his clothes. Rubber boots are objectionable in creameries and are needless if the floor is kept properly dry. Basins, good soap, and clean towels should always be available in every creamery; the presence of these things suggests their use.

SOME STANDARD VARIETIES OF CHICKENS.[1]

By George E. Howard,
Secretary of National Poultry and Pigeon Association.

[The term "poultry," as used in this article, does not include ducks, geese, or turkeys, but is restricted to what, for want of a more specific designation, is commonly known as the barnyard fowl, or common chicken. Of these, there are, according to the writer of the article, 87 standard and a large number of promiscuous varieties raised in this country. Only a few of the most important are treated of in this article.]

PLYMOUTH ROCKS.

The Plymouth Rock is the most popular of all varieties of poultry as a general-purpose fowl. Its medium size, hardy growth, and good laying qualities make it a practical fowl for the farm. The Barred variety is the most generally known of the Plymouth Rocks, and its history dates back a little over a quarter of a century. Various bloods were used in its making, the belief being general that it originally came from a cross between the American Dominique and the Black Java. It has also been shown that the light Brahma, Dark Brahma, and Pit Game have been used in its making.

The Barred Plymouth Rock (fig. 108) is of a grayish-white color, regularly crossed with parallel bars of blue-black running in straight, distinct lines throughout the entire length of the feather, and showing on the down or undercolor of the feathers. The barring is somewhat smaller on the hackle and saddle feathers than on other portions of the body. The bird is of medium size, with broad neck, flat at the shoulders, the breast is full, and the body broad and compact; medium-sized wings, that fold gracefully, the points being well covered with breast and saddle feathers; a medium-sized head, ornamented with upright, bright-red comb and wattles, a large, bright eye, and yellow beak, legs, and toes, place the picture before us in its entirety. The difference between the Barred and the Pea-comb Barred is that the latter has a small, firm, and even pea comb, instead of single comb.

With the farmer or market poultryman these birds are favorites, being of medium size, well proportioned, with a deep, full breast, and thus admirably adapted for market purposes. They are hardy, mature early, and make excellent broilers when from eight to twelve weeks old. They are good layers the year round, and in winter they lay

[1] From "Standard Varieties of Chickens," by George E. Howard. Farmers' Bulletin No. 51, Bureau of Animal Industry, U. S. Department of Agriculture, 1897.

exceptionally well. Their eggs are brown in color and average eight to a pound. They are good sitters and excellent mothers.

The Barred Plymouth Rock, besides being a practical fowl, is also one of the most sought after by fanciers. No class is better filled at the average poultry show of the country than is this. Their graceful figure, upright carriage, and active natures endear them to all as a fancier's fowl. There is a fascination in breeding them for plumage, the more regular and even their barring the better. It requires much skill to breed them for color, and two matings are generally used for breeding. A rule is established in mating for cockerels to use a standard-color male with medium-dark females, and for pullets to use light male and dark females. The double mating is resorted to by many, yet the writer has seen rare specimens produced from single matings.

The characteristics of the Barred Plymouth Rock, excepting that of color, are noticeable in the other varieties of Plymouth Rock. The size, shape, general outlines, and qualities are the same in the other varieties as in the Barred. The White Plymouth Rock is pure white in plumage throughout, and the buff variety is a clear buff, uniform in shade except the tail, which is deep buff or copperish-yellow brown. The buff color should extend to the undercolor as much as possible; the deeper the better.

The standard weight of cocks is 9½ pounds; hens, 7½ pounds; cockerels, 8 pounds, and pullets, 6½ pounds.

WYANDOTTES.

The Wyandotte (fig. 109) is another of the general-purpose fowls, and is rated next to the Plymouth Rock. From the first it sprang into popular favor and has continued so to the present time. Its origin is comparatively recent, dating back less than twenty-five years. It came originally from the Dark Brahma, the Silver-spangled Hamburg, and the Breda, a French fowl. Not a few authorities say that Wyandottes have Cochin blood in them, from the fact that their ancestors produced single combs and feathered legs.

For general purposes the Wyandotte has proved a success, being of medium size, weighing on an average a pound less than the Plymouth Rock fowl, hardy of constitution, and a prolific layer. It is easily cared for and bears confinement well. For table purposes, it is of superior worth; its flesh is sweet, juicy, and tender, excellent for broiling and roasting. As a layer it is among the best, averaging from twelve to fourteen dozen eggs a year, and as a winter layer it does well under ordinary circumstances.

There are five varieties of the Wyandotte breed, and it is entirely a matter of opinion as to which is the best. The general characteristics are the same in them all, the difference in color of plumage being

the only distinguishing mark. The Silver-laced Wyandotte is of a silvery-white plumage, with regularly-marked white lacing on breast and a generous distribution of white and black throughout the entire body. The cock has a silver-white head, rose comb, silver hackle, with a black stripe down the center of each feather; silvery-white back; saddle same as hackle; breast black, with white center; tail black; wings half black and half white, or, rather, black edged with white; when wing is folded there should be a well-defined bar across the wing; shanks and toes rich yellow, free from feathering. The hen of the Silver-laced variety (fig.110) is marked similarly to the male, excepting the back and wing, which are whiter in male than in female. The breast of the female is of much importance in breeding good birds; the lacing should be large and distinct, and the white centers of each feather free from black or brown penciling.

The Golden Wyandotte is marked like the Silver, excepting that the color is golden-bay and black instead of white and black. The White variety is, perhaps, the favorite of the Wyandotte class, from the fact that it is not so difficult to breed to feather, the plumage being pure white throughout. It is for this reason the more practical fowl for the farmer, or those who raise poultry for market. The Buff Wyandotte is in color a rich, deep, clear buff, uniform in shade throughout, except the tail, which is of a deeper buff or copperish-bronze color. The Blacks are of a rich, glossy black, with greenish sheen, excepting breast primaries, secondaries, tail and fluff, which are pure black.

The standard weight of cocks is 8½ pounds; hens, 6½ pounds; cockerels, 7½ pounds, and pullets, 5½ pounds.

DOMINIQUES.

Similarity in plumage of the American Dominique and the Barred Plymouth Rock has been the cause of the former's popularity. Its color is grayish-white, each feather regularly crossed with parallel bars of blue-black, producing the effect of a bluish-tinged plumage, the color being the same throughout. It has a rose comb, in both male and female, and bright yellow legs. Those who are partial to the color of its plumage will find the Dominique a good bird to keep. It is a good layer, is hardy, matures early, and dresses well for the table.

The standard weight of cocks is 8½ pounds; hens, 6½ pounds; cockerels, 7½ pounds, and pullets, 5½ pounds.

JAVAS.

This variety is the oldest of the American class, and at one time was considered the most profitable of all breeds. At present it is not raised extensively, the more modern or newer breeds having seemingly supplanted it. There is no reason why this should be so,

as it is a practical and good general-purpose fowl. In size it is about like the Plymouth Rocks, but differs in general symmetry and appearance. It is a good layer and does well in winter, and for table purposes it makes nice eating. Javas mature early, are good sitters and mothers, and are easily kept in confinement.

There are three varieties of Javas: Black, Mottled, and White. The Black (fig. 111) is more generally seen than the others, though the Mottled has of late years been very numerously represented at the shows. The plumage of the Blacks is glossy black throughout; the Mottled (fig. 112) is of broken black and white in wings, tail, and sickles, and the remainder of the plumage is evenly intermixed with white and black; the White Java is, as the name implies, pure white throughout. It has a small single comb, standing upright on the head in both male and female. The shanks and toes are free from feathers, yellow in color, with the bottom of feet yellow.

The standard weight of cocks is 9½ pounds; hens, 7½ pounds; cockerels, 8 pounds, and pullets, 6½ pounds.

BRAHMAS.

The leading variety of the Asiatic class is the Light Brahma (fig. 113). This fowl has a history that would fill pages were it recorded. It is the fowl which caused the "hen fever" of the fifties, about which so much has been written in later years. Its early history is a matter of controversy, the best authorities differing as to its origin.

Brahmas were first known as "Brahma Pootras," "Gray Shanghais," "Chittagongs," "Cochin Chinas," and what not. The early breeder named them according to his fancy for high sounding and sensational names to sell his stock. Fabulous prices were paid for them when the craze for fine poultry was at its height in the early days of the last half of the present century. The standard of the present Brahma fowl was fixed in 1869, and no deviation from the type then adopted has been made. It has stood high in popular favor since then without abatement; the vast number of breeders who are raising it fully attest its worth as a practical bird to the industry. The Brahma is a characteristic fowl; it is unlike other varieties, and it should not be confounded in shape with the Cochin.

The average Light Brahma male is in height 26 inches; back from the ground, 16 inches; keel from the ground, 8 inches; length of body, front of breast to rear of fluff, 14 inches; height of tail, a trifle over 21 inches; saddle hangers to rear of fluff, 2¼ inches; from eye to tip of beak, 2¼ inches; length of head and beak, 3½ inches; breasts to rear of a drop line from point of beak, three-fourths to 1¼ inches. As specimens depart from this proportion they become awkward and valueless as exhibition stock, and often also as egg producers. In shape, oblong, with full, broad, and round breast, carried well forward. The fullness and oblong shape is typical of the Brahma and is characteristic of

prolific birds. The curves of the neck and back are similar to those of an egg.

In plumage the male is pure white, excepting hackle, tail, and flights, which are black, and white striped with black. Any other color but white and black is against the standard-bred bird. The hackle is white, with a black stripe extending down the center of each feather and tapering to a point near the extremity. The tail feathers are black, and sickles are glossy greenish-black. The shanks are well feathered, with the feathering extending down the middle toe; the toe feathering may be white or white sprinkled with black, pure white preferred. A small pea comb, broad crown, projects over the eyes; bright-red

FIG. 108.—Pair of Barred Plymouth Rocks.

face, wattles, and ear lobes being essential to a good head. The shanks and toes are bright yellow.

The Brahma female is much like the male in head qualities, having broad comb, projecting well over the eyes, and small pea comb. The head of the female should be masculine in appearance, indicating great will power. The head is white; hackle, white, striped with black, as in male; cape, white and black, but is completely covered by hackle when the bird stands erect; tail, black, excepting the two highest main tail feathers, which may be edged with white; tail coverts, one or more rows, distinctly covering a part of both sides of the main tail, two being preferable, are black, edged with white.

The Light Brahmas are valuable birds for the farm. They have

always been made to pay for their keep and have seldom been set aside by any who have bred them. They are the largest of domestic poultry and do as well in confinement in small runs as on free range. As layers they will average from twelve to thirteen dozen eggs a year, and lay exceptionally well in winter. Their eggs are large, about seven to a pound, of a rich brown color and excellent flavor. For table purposes

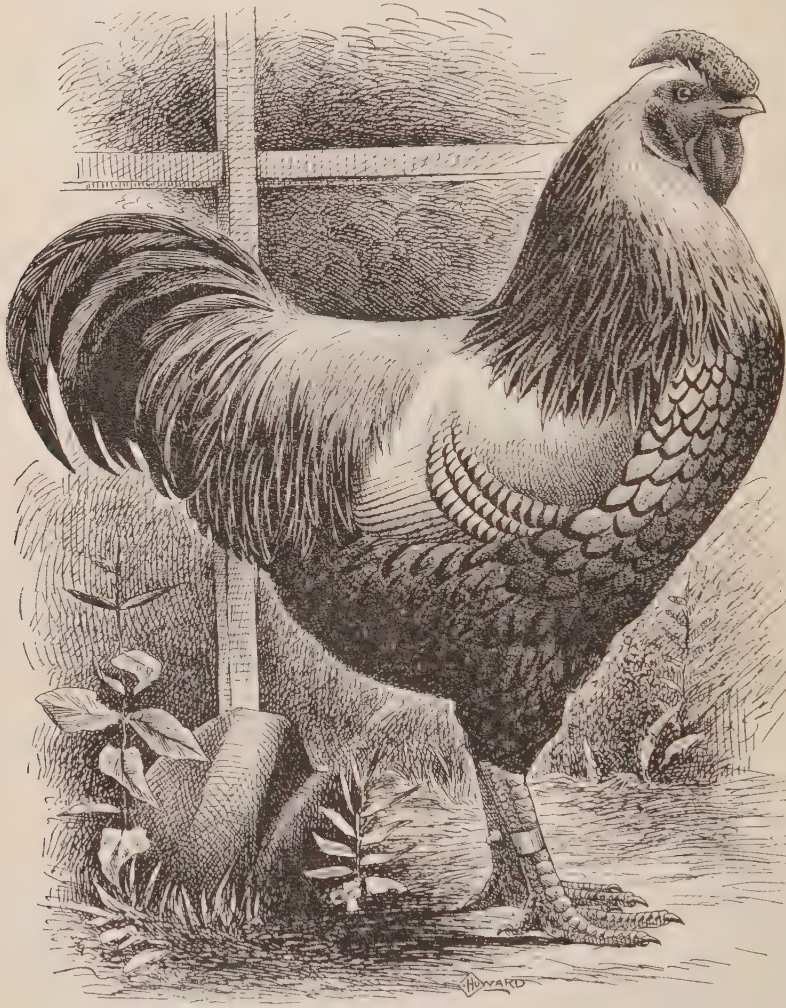

FIG. 109.—Silver-laced Wyandotte cockerel.

the birds are good; they do not mature as early as do the varieties of the American class, yet they are hardy, and can be raised with as much ease as any of the earlier-maturing varieties. As sitters and mothers they are fair.

The Dark Brahmas are not so popular as the Light, the difficulty

being in breeding them true to feather. Their delicately-marked plumage is extremely pretty when bred to standard requirements, but if not so bred it becomes most disagreeable and unsatisfactory to the breeder. The head and neck of a Dark Brahma male are similar to those of the Light, the head being white and the hackle rather more striped. The back is nearly white, a little black appearing here and there. The black should predominate between the shoulders, but is nearly hidden by the hackle flowing over it. The saddle feathers are, like the hackle, silvery-white, striped with black, which should be distinct. As the feathers approach the tail the stripes become broader till they merge into the tail coverts, which are rich, glossy green-black, with a margin or lacing of white. The tail is pure black, with green gloss. The wing coverts are black, forming a distinct black bar across the middle of the wings, while the ends of the secondaries have a large black spot on them, making the top edges of the wing appear almost black. The remainder of the secondaries are white on the lower half and black on the upper. The flights are all black, except a narrow fringe of white on the lower edge. The breast is black; the thighs and fluff either black, or black, very slightly mottled with white. The shank feathering should correspond with the breast, being black if the latter be black, and slightly mottled with white if not. The shanks are deep yellow, inclining to orange.

FIG. 110.—Silver-laced Wyandotte pullet.

The color of females is a white ground, closely penciled with dark steel-gray, producing a beautiful effect, frosted or silver-gray in appearance. There should be no show of pure white in the plumage except in the margins of the hackles. Unless extreme care be taken in mating, the hens are likely to have a dingy color, and the pullets are apt to have necks almost white for some distance down. These light-necked birds generally breed to worse, but the evil may be remedied by choosing birds for breeding whose heads are distinctly marked. The shape and character of the markings of the Dark Brahma pullets also vary. They should be medium sized, so that the pencilings can be clearly discerned at a short distance. A great point in regard to color and marking in Brahma pullets is that they should be uniform over the body, and

the hackles should be silvery-white, heavily striped with rich black, and the shank feathering penciled same as body.

For practical purposes, the Dark Brahmas are not to be commended as highly as the Light. The close breeding for points in feathers is likely to interfere with their productiveness, yet with proper attention and care they can be bred profitably as well as for beauty.

FIG. 111.—Pair of Black Javas.

The standard weight of Light Brahma cocks is 12 pounds; hens, 9½ pounds; cockerels, 10 pounds, and pullets, 8 pounds. The standard weight of Dark Brahma cocks is 11 pounds; hens, 8½ pounds; cockerels, 9 pounds, and pullets, 7 pounds.

COCHINS.

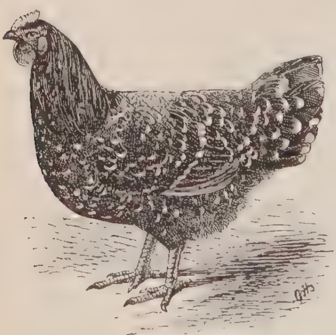

FIG. 112.—Mottled Java hen.

The four varieties of Cochins are very popular with breeders. They are second to the Brahmas in the meat breeds, weighing but a pound lighter than the Light Brahma. Old and experienced breeders of Cochins are pronounced in praise of their qualities as profitable fowls. They are hardy, good winter layers of rich, brown, medium-sized eggs, and fairly good table fowls. The chicks grow well and develop rapidly under proper care.

The Buff variety (fig. 114) are the most generally bred; their soft, mellow, buff tone offers an attraction to fanciers that is hard to resist. In color the Buff Cochin, male and female, is of a rich, deep, clear buff, uniform in shade throughout except the tail, which should be a deeper buff or copperish-bronze, undercolor same as surface color,

but of lighter shade, and should extend to the skin. In breeding, select females as near as possible to the desired shade of buff, as free from dark or white in wing and tail and of as even a color as can be. To such females mate a cock of deeper shade, with some little black in wing and tail of deep buff of a coppery luster. This mating will produce good results in cockerels and pullets. The heavy leg and foot feathering so characteristic of the breed should have constant care and attention. While the feathering should be abundant, all semblance to vulture hock or stiff feathering should be avoided.

The Partridge Cochin is a beautiful yet difficult fowl to breed, and

FIG. 113.—Pair of Light Brahmas.

in plumage is much after the pattern of the Dark Brahma, the color being red and brown, instead of the steel-gray effect of the latter. The head of male is in color bright red; hackle, bright red or orange red, with a distinct black stripe down the center of each feather; saddle feathers, same as hackle; breast and body, rich deep black; wing bows, red; primaries, black on inside web, with a bay edging on the outside web; secondaries, black on the inside web and rich bay on the outside web, terminating with greenish-black at the end of each feather; wing coverts, greenish-black, forming a well-defined bar of that color across the wing when folded; tail, black; sickles, coverts,

and lesser coverts, glossy greenish-black; the latter may be edged with red; thighs, black; shanks, yellow and well covered with black or brownish feathers, the middle toes being also well feathered.

The female is the prettier of the two. Her head is small and of a rich-brown plumage, with a stout, well-curved beak, yellow in color. Her eyes are bay and mild in expression. The head is ornamented with a small single comb, set perfectly straight upon the head and bright red in color. The wattles are small, well rounded, and fine in texture; the ear lobes are well developed and are also fine in texture.

The neck is neatly curved, with abundant hackle flowing well over the shoulders. The plumage is bright red or orange red, with a broad black stripe down the middle of each feather. The black stripe in a good feather should run to a point near the end of the feather. This

FIG. 114.—Pair of Buff Cochins.

stripe should be free from peneiling, but the standard permits a slight penciling of the black.

A good back and cushion help to make the bird. Her back should be broad and flat, the broader the better, and the cushion should rise with a gentle convex curve and partially cover the tail. The plumage of back and cushion is a reddish-brown in color. Each feather is penciled with a darker brown; the outlines of the penciling conform to the shape of the feather. The breast is one of the most important points of a good hen, and should be broad and massive. The plumage is of the same reddish-brown color as the back. The penciling on the breast is perhaps a little more distinct and open than on the back; the outlines of the penciling should be sharp and conform to the shape of the feather.

The body is broad and deep behind and of the same plumage as the breast. The fluff is very abundant, covering the posterior portion of the bird and standing out about the thighs. Wings are small and the primaries fold closely under the secondaries; the bows are covered by the breast feathers and the fluff conceals the points. The primaries are very dark brown or blackish-brown in color; the inner web of the secondaries is a blackish-brown, and the outer web is a blackish-brown penciled with a lighter brown. The coverts are similar in color and penciling to the plumage of the breast.

The tail is small and short, is carried almost horizontally, and is partly concealed by the cushion. In color it is black, except the two main tail feathers, which are penciled. The tail coverts are penciled

FIG. 115.—Pair of Black Langshans.

same as breast and body. Thighs are large and well covered with soft feathers; the feathers on the lower part curve inward around the hock and hide the joint on the outside. The feathering of the thighs is of the same shade and color as that of the body. Shanks are short and yellow and heavily covered with feathers of same color as thighs. The toes are well spread and yellow in color, the outer and middle toes being feathered throughout their entire length.

Black Cochins are much more easily raised than are either of the varieties thus far described. Being of one color, the care bestowed in breeding party-colored or penciled birds is not necessary, and the time may be spent in furthering their general utility in egg production. A

one-colored bird is the more practical bird for the farmer and market poulterer. The Black Cochin is of a rich glossy-black plumage throughout. The White Cochin is pure white in plumage.

The standard weight of Buff, Partridge, and White Cochin cocks is 11 pounds; hens, $8\frac{1}{2}$ pounds; cockerels, 9 pounds, and pullets, 7 pounds. Black Cochins are of the same weight, excepting cocks, which should weigh $10\frac{1}{2}$ pounds.

FIG. 116.—Single-comb White Leghorn cock.

LANGSHANS.

The Langshan is the smallest and most active of the Asiatic class. It is a practical fowl in more senses than one, and its prolific laying and excellent qualities make it a profitable fowl for the farmer and market poultryman. It is one of the oldest breeds of poultry and has always been held in popular esteem. The shape of the Langshan is distinct from that of the Brahma or Cochin, and should not be confused with either of the last-named breeds. Fig. 115 shows the accepted contour of the Langshan, and a comparison with

the birds illustrated by figs. 113 and 114 shows at a glance the characteristics of the Langshan as compared with the other Asiatics. Langshans have white flesh and dark legs, while the others are yellow skinned and yellow legged. The flesh of the Langshan is excellent, being fine grained, tender, and good flavored. As layers these birds rank among the best, averaging from twelve to thirteen dozen eggs a year, and as winter layers they are to be recommended. The chicks are hardy and mature early. Langshans are good sitters and mothers, being of gentle disposition; they are easily kept either in confinement or on free range. Being excellent foragers, they are ideal fowls for the farm, and will gather during the year a considerable proportion of their food.

FIG. 117.—Head of Single-comb Brown Leghorn hen.

The Langshan is a stylish, medium-sized bird, not overgrown or gawky in appearance, of active nature, and lively disposition. Many confound the Black Langshan with the Black Cochin. This need not be, as the following comparison between the two varieties shows: The Black Cochin is square in shape, with heavy-looking neck and legs, plenty of fluff and leg feathering, cushion rising from middle of back to tail; tail short, small, and almost concealed by cushion; neck, breast, cushion, and tail all represented by convex lines. Langshan, head small for size of body, comb medium sized, well up in front, and arch shaped. Cochin, head larger than that of the Langshan and not so arched over the eye; comb smaller, low in front, and almost straight on top of serrations. Langshan, back short and concave; that of the Cochin medium length, slightly convex, and large convex cushion. Langshan, fluff moderate and close; that of the Cochin extremely full and loose. Langshan, wings somewhat large and inclined downward, quite prominent at shoulders; the Cochin wings smaller and almost hidden by the fluffy plumage of cushion and fluff. Langshan, breast full, deep, and carried well forward; Cochin, breast not so full and deep, but broader. Langshan, legs medium in length, small bone, long tapering toes,

FIG. 118.—Head of Single-comb Brown Leghorn cock.

color of shank bluish-black, showing pink between scales, which are nearly black; Cochin, legs shorter, stouter, larger bone, toes shorter and stouter, color of shanks black or yellowish-black.

There are two varieties of Langshans: the Black and the White. The Black in plumage of neck, back, saddle, sickles, a glossy metallic black, with greenish sheen; breast, primaries, secondaries, tail, fluff, shank, and toe feathers, black. The undercolor is black or dark slate. The White Langshan is pure white throughout.

The standard weight of cocks for both varieties is 10 pounds; hens, 7 pounds; cockerels, 8 pounds, and pullets, 6 pounds.

LEGHORNS.

Leghorns are the best known of the egg-producing varieties or Mediterranean class. They are the premiers in laying and the standard by which the prolificacy of other breeds is judged. As to the origin of the Leghorn fowl, there are differences of opinion, and there is but little information to be found anywhere concerning its early history. It is generally conceded that a race of fowls bearing a close resemblance in many respects to the Leghorn has existed in Italy and other parts of the Continent of Europe for a long period. That this race of fowls has been widely disseminated admits also of little doubt, inasmuch as at the present day the breed is known in Denmark and other countries as the Italian. There seems to be good ground for the statement that Leghorns were first introduced into America from Italy. The story goes that as early as 1834 a vessel from Leghorn, Italy, brought to this country as a part of its cargo a small shipment of fowls, which were at once named "Leghorns." They immediately became popular, their prolific laying and nonsitting qualities being recognized at this early date.

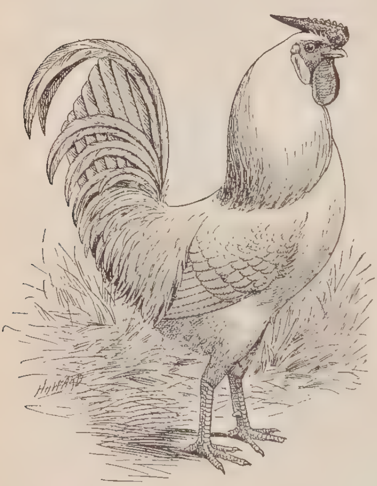

FIG. 119. Rose comb White Leghorn cockerel.

White and Brown Leghorns were the first varieties known. Modern breeders are responsible for some of the subvarieties of the breed, and, in point of color at least, exhibition birds of to-day, even of the older varieties, vary considerably from those seen at the present time in Italy.

The Leghorn fowl holds the same place among poultry that the Jersey holds among cattle. The question of profit in poultry has been decided in favor of egg-producing breeds. Leghorns are lively, active,

and of a restless disposition, the best of foragers, and will pick up a good part of their living during the year. They are light eaters and the cost of raising them to maturity is about one-half that of the Asiatic varieties. They mature early, feather quickly, the pullets often begin laying when 4 months old, and cockerels crow at the same age. They are the best layers, averaging between 150 and 200 eggs

FIG. 120.—Black Minorca cockerel.

per year. Their eggs are pure white in color, and weigh about ten to the pound. As table fowls they are fairly good. By many they are considered excellent. The only thing that can be said against them is that they are small in size. Altogether, they are one of the most profitable breeds of poultry that can be kept upon the farm, and the cheapness of their keeping will allow the raising of two Leghorns for the cost of one Asiatic. They must be warmly housed in winter to lay well and to protect their pendulous wattles from frostbite.

In shape a Leghorn cock (fig. 116) should be graceful; body, round and plump, broad at the shoulders, and tapering toward the tail. The tail should be well balanced on a fair length of shank and thigh; the length of leg giving the bird its sprightly and proud carriage. Closeness of feathering adds to the general shape and secures a freedom from angles which always proclaims the pure bred, typical specimen. The breast should be full, beautifully curved, rather prominent, and carried well forward. Neck, long, well arched, and carried erect; back, of medium length, with saddle rising in a sharp, concave sweep to the tail; tail, large, full, carried upright; the full, flowing tail, and long, well-curved sickles are characteristics of the bird that are much thought of. The wing is long, well folded, and tightly carried.

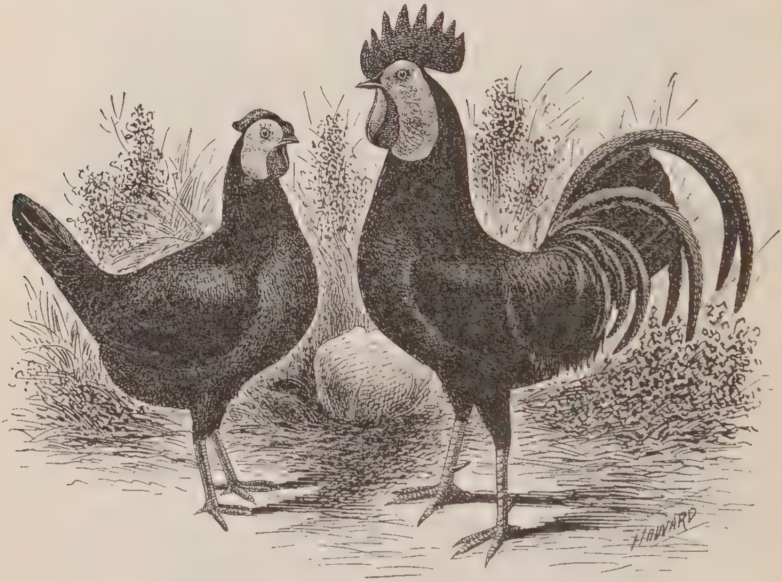

FIG. 121.—Pair of White-faced Black Spanish.

Hackle and saddle feathers, long and abundant and flowing well over the shoulder and saddle. The legs are bright yellow and free from feathers; toes also yellow, but a dark shade is allowable. The head is the prettiest portion of the bird, being short and deep, yellow beak, full, bright-red eyes, and bright-red face. The comb is single, of medium size, perfectly straight and upright upon the head, free from side sprigs, deeply serrated with five or six points, and bright red in color. The comb should extend well back over the head, with no tendency to follow the shape of the neck. Ear lobes white, or creamy white.

The Leghorn hen in many respects resembles the cock, excepting carriage of comb and sexual differences. In shape and carriage the hen is even more graceful and sprightly than the cock, very close in feather, and rather small in body, though somewhat long in back.

Her breast is full, very round, and carried high; legs fairly long, and shanks thin; tail carried closely and well up. The general carriage should be upright. Her comb is the marvel of her beauty; it is single and falls gracefully to one side, but not in a limp manner, or so as to obscure the sight. Fig. 117 shows an ideal comb of Leghorn female. Legs, comb, and face are the same color as in the male, but the ear lobe is much smaller.

There are six standard varieties of Leghorn: Black, Brown, Buff, Dominique, Silver Duckwing, and White.

The Black Leghorn is a popular bird, and a favorite with those who are partial to its color of plumage. The Black Leghorn is mistaken by many for the Black Minorca, but is quite different in type. The Minorca is larger in size, has a longer body, larger comb, and dark

FIG. 122.—Pair of Silver-spangled Hamburgs.

slate or nearly black shanks and toes. The plumage of the Black Leghorn is a rich glossy black throughout. Comb, face, and wattles, bright red; ear lobes white; and shanks yellow, or yellowish-black.

The Brown Leghorns (fig. 118) are among the prettiest as well as the most commonly bred of the Leghorn varieties. They are the most difficult of all to breed to feather. They have merited the confidence of poultry lovers for a long time and their hardy constitutions have thwarted rough usage and promiscuous interbreeding to efface their characteristics. They are a fixed breed, and their merits are noticeable from the newly-hatched chick to the oldest specimen; they are stamped with the indelible marks of royalty to be found only in a thoroughbred.

In mating Brown Leghorns opposites must be considered. Should the male be fine in all points except comb or leg, select females strong in this point to mate with him. The most successful breeders use a double mating, one pen to produce exhibition birds of each sex.

Fine birds, both cockerels and pullets, can be bred from the same pen by using slightly different types of females. The same male often will breed the finest of both exhibition cockerels and pullets, but it is a rare case to have a female breed both sexes of a remarkable quality. When two pens are used, at the head of the pen mated to produce the cockerels place a fully developed cock with no serious fault, standard color, especially strong in comb, lobe, hackle, and saddle, a dark undercolor preferred. To him mate hens of a shade darker than standard, with small, evenly serrated, standing combs; a trifle brick color on wings is no objection, as it will give a brighter color on wing bows of the cockerels. Shafting on the back will also help the black stripe in the saddles. The pullets raised from this pen will be too dark for exhibition, but they will be a great help in breeding cockerels the next season. The male at the head of the pen mated to produce the pullets should be from a pullet strain, and bred directly from an exhibition hen. His color is a trifle light; comb large, but evenly serrated; if thin near the top, all the better; hackle well striped, but none in saddle; undercolor of hackle and saddle may be light gray or white; wing bows should show more purple than red, as too much red shows signs of being bred from a bricky hen. To him mate exhibition females having light brown penciled with darker brown on back and wings, all one shade, free from shafting on back and brick on wings. These hens should have the large comb, lying over, but firm and strong on the head, so as not to lie close to the eye and face. The cockerels raised from this mating are the birds to use for breeding females the next year. By breeding Brown Leghorns in this manner we have two distinct lines of blood, and they should never be crossed.

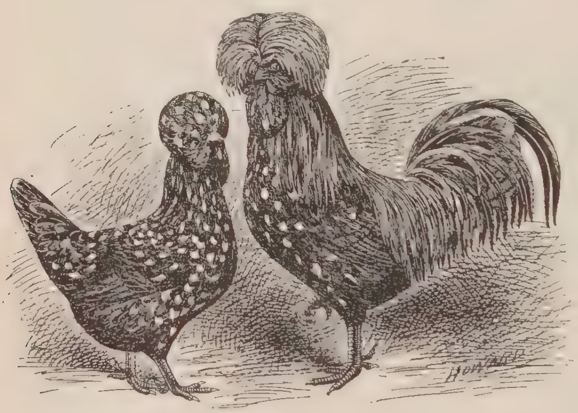

FIG. 123.—Pair of Houdans.

The Buff Leghorn is the most recent acquisition to the Mediterranean class. It is a beautiful bird, and one that will win its way wherever bred. Buff-colored birds have many admirers, and those who have bred them are most pronounced in praise of their qualities. Besides having the general characteristics of the Leghorn type, the Buff Leghorn cock has rich buff-colored hackle and saddle, in shade from lemon to cinnamon, but of even solid color in keeping with the

rest of the plumage; the back and the wing bow exactly match the plumage; tail is of the same general tint, but richer, deeper buff is preferable, the standard giving for tail a rich, deep buff or copperish-bronze. The remainder of the plumage is of a slightly lighter shade, but even in color throughout, with no semblance to a patchy or mottled plumage. White and black feathers in plumage are objectionable; solid white or solid black feathers will disqualify the bird. The hen is of the same color as the cock.

Dominique Leghorns are not so generally known. Their color is much like that of the American Dominique and Barred Plymouth Rock, and is what is known as "Cuckoo" by English breeders. The body color is grayish-white, each feather regularly crossed with parallel bars of blue-black, producing the effect of a bluish-tinged plumage. This color is the same throughout. The ground color of each feather is a clear, light, bluish-gray. The shanks and toes are bright yellow and eyes bright red.

FIG. 124.—Silver Gray Dorking cock.

Silver Duckwing Leghorns are not generally bred in this country, though they are frequently seen in the show-rooms. They are considered as profitable as any of the other Leghorn varieties, and in point of beauty they are very interesting and fascinating. They take the name "Duckwing" from the similarity of the steel-blue wing bar to that of the Mallard, or Wild, Duck, the name being first given to a variety of games—the Silver Duckwing Games. The hackle and saddle feathers of a Silver Duckwing Leghorn cock are pure silvery-white, without the slightest straw or creamy tinge, with a narrow black stripe along the center of the lower hackle feathers. Back, saddle, wing bow, and wing bay, pure white; breast, underparts, wing bar, and tail dense lustrous black. The Silver Duckwing Leghorn hen has a silvery-gray hackle, with a narrow black stripe through the center of each feather. The breast is light salmon, shading off to gray toward the sides; the body color when viewed at a short distance should appear gray, with a faint bluish tint all over. Tendency to ruddy gray, either in ground color or penciling, is objectionable.

The tail is black or dark brown, except the two upper feathers, which are light gray. The pencilings or markings are irregular or wavy.

The White Leghorn, like the Brown, is one of the most generally bred of the Leghorn varieties. It is, no doubt, the most advantageous variety to breed for profit and the easiest to raise on the farm. Being of one color in plumage, these birds are more successfully raised and cared for than the party-colored varieties. Their plumage is pure white throughout, and feathers other than white will disqualify them. It has been a matter of much speculation as to which variety of Leghorns is most prolific in egg production. This is a difficult question to properly adjust to the satisfaction of the specialty breeders, but from a conservative standpoint it is generally considered that the Whites have slightly the advantage over the others. Phenomenal individual egg records have been made by almost all the varieties, but the opinion here expressed is based on general results obtained from various sources.

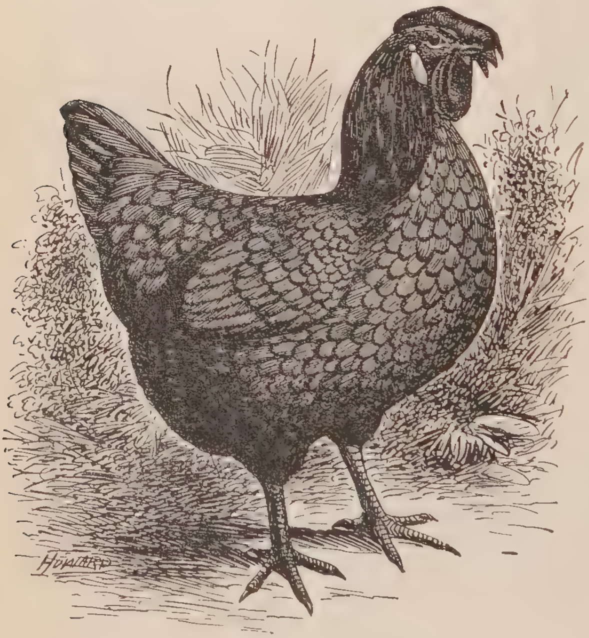

FIG. 125.—Blue Andalusian hen.

There are subvarieties in Brown and White Leghorns—the Rose-comb Brown and the Rose-comb White. The only distinguishing difference between the last-named and the other varieties is in the comb. The Rose-comb White and Rose-comb Brown Leghorns have a small rose comb (see fig. 119), square in front, firm and even upon the head, tapering evenly from front to rear, without inclining to one side, the top comparatively flat and covered with small points or corrugations, terminating in a well-developed spike in the rear. There is no standard weight given for Leghorns.

MINORCAS.

The Minorcas (fig. 120) belong to the Mediterranean class, and are placed next to Leghorns in laying qualities. They are in appearance very similar to the Leghorns. Their general outline is, in fact, that

of the latter, but they have greater length of body and are heavier in mold. Indeed, they are the only variety of the Mediterranean class that has a given weight which approaches that of the Wyandotte, being only one-half pound lighter than the last named. The origin of the Minorcas, like that of so many others of our profitable poultry, is much in doubt. Some are of the opinion that they originally came from Minorca, one of the Balearic Isles in the Mediterranean Sea, while others contend they are a variety of the Black Spanish. Be that as it may, they are one of the most profitable breeds of poultry for the farm that is known.

For table purposes they are good, the flesh being white or light colored, and fine grained. Their chief value, however, is as egg producers. They are nonsitters and year-around layers. As winter layers they are exceptionally good when kept under fairly favorable circumstances. While the Leghorn surpasses them in the number of eggs laid, the Minorca's eggs are larger, and equal the output in bulk. Their eggs are white, and average eight to the pound. They lay from twelve to fifteen dozen a year. For farm purposes they are especially profitable. Being of an active, restless disposition, they keep in splendid condition and make good foragers. For suburban poultry keeping they are very practical birds and net good results to the keeper. They are hardy, easily raised, and mature quickly.

The Minorca fowl is large in outline, well bodied, stands well up on its legs, has a broad chest, and a long, flat back, with tail carried upright. Many breeders dispute as to the carriage of the tail. The standard says "upright," while the preference is almost universally made by breeders that it should be carried "well back." The upright position gives the tail the Leghorn type (see fig. 116), while the typical Minorca differs somewhat from it by being more horizontal, as shown in fig. 120. The body of the Minorca male is long, square in front, tapering from front to rear. When standing erect, the body of male is at an angle of nearly forty-five degrees. Thighs are stout; shanks, medium in length, stout in bone, and in color dark slate or nearly black; comb, single, large, perfectly straight and upright, evenly serrated, and extending well over back of head. The comb of the Minorca is larger and more bulky than that of the Leghorn. Wattles are thin and pendulous, corresponding with size of comb; ear lobes, pure white. The female is in body of the same general appearance as the male, rather long, broad, and deep. Her comb is single, large, and drooping to one side; like comb of male, her comb is perceptibly larger than that of the Leghorn female. Black Minorcas are in plumage a rich, glossy black throughout, and gray tips are considered serious defects. The White Minorca is as popular as the Black, and takes the same position as does the White Leghorn in its class. The choice is only that of color; the other qualities are equal as to profitableness between the

two varieties. The standard qualifications are equal for the two except in color, and that must be pure white throughout, feathers other than white disqualifying. The comb, face, and wattles are bright red, free from white in face; eyes are dark hazel or red.

Before leaving Minorcas it is worthy of note that the latest acquisition to the Minorca breed is the Rose-comb Black Minorca. The only objection that has ever been raised against the varieties of the Mediterranean class is their susceptibility to frostbite of the comb. Their combs are so large that continued cold or exposure is sure to result in this injury. To obviate this one defect, if it may be so termed, in this valuable class of birds, it has been the aim of breeders to produce a bird possessing the other qualifications, but with low rose comb. There are two varieties of Rose-comb Leghorns (the Black and the White) and there is the Rose-comb Black Minorca. The latter is not a standard variety as yet, but indications point to its admission as such in the near future. Many good specimens have been bred and exhibited at the recent shows, and success in making this new fowl seems assured. The head of the Rose-comb Black Minorca male should be medium in length; beak, stout and black; eyes, dark red; face, smooth and red; comb, rose, straight, and set close and even on the head. In size the comb should be between that of the Wyandotte and the Leghorn; wattles, medium in length and not so large as in single-comb variety; ear lobes, pure white, large, smooth, and almond-shaped. The head of the female is similar to that of the male—medium in size; face, red; comb, small and even on the head; wattles, medium in size, thin, and bright red; ear lobes, pure white, large, and even.

The standard weight of a Minorca cock is 8 pounds; hen, 6½ pounds; cockerel, 6½ pounds, and pullet, 5½ pounds.

BLACK SPANISH.

The Black Spanish (fig. 121) is one of the oldest varieties of domestic poultry. Its name has been identified with the industry for hundreds of years, and its practical value on the farm has long been recognized. Its haughty bearing, large red comb and wattles, and the white face and lobes peculiar to the breed, contrasting with its glossy-black plumage, render it a most striking fowl.

White-faced Black Spanish have long been favorably known for their exceptionally fine laying qualities. The oldest of the nonsitting varieties, they still maintain an unsurpassed record. The pullets are early layers, averaging 150 to 180 eggs per year, the hens beginning somewhat later after molting, but compensating for any loss of quantity by the increased size of the egg, while hens and pullets alike are above the average for winter laying. Their eggs are large and white and of good flavor. The bird's white face is a distinguishing feature, and should be long, smooth, free from wrinkles, rising well

over the eyes in an arched form, extending toward the back of the head and to the base of the beak, covering the cheeks and joining the wattles and ear lobes, the greater the depth of surface the better, and should be pure white in color. The color of plumage throughout is rich, glossy black, and any gray in plumage is considered a serious defect. Shanks and toes are blue, or dark leaden-blue. Comb is single and bright red in color; wattles, bright red, except the inside of the upper part, which is white; ear lobes, pure white.

No standard weight is given for Black Spanish; they equal in size the Leghorn and Andalusian.

HAMBURGS.

Hamburgs (fig. 122) are in the front rank of egg producers, and are in general appearance much like Leghorns. There are six varieties of Hamburgs: The Golden-spangled, Silver-spangled, Golden-penciled, Silver-penciled, Black, and White. They are all very pretty birds and seldom fail to prove attractive and profitable to the average breeder and fancier. Hamburgs are economical fowls to keep; besides being light eaters and great foragers, they are prolific layers and non-sitters. The only thing against them is the smallness of their eggs. They lay a pretty, white-shelled egg, but smaller in size than those of the Leghorn. There are some which lay larger eggs than others, and by careful selection from year to year of the birds which lay the largest eggs this defect may be remedied and the size of the eggs improved.

The Silver-spangled Hamburg is, perhaps, the most beautiful as well as the most popular variety of the Hamburgs. Its proud carriage, royal decoration, and graceful and symmetrical form command attention wherever seen. Breeders of Hamburgs universally adopt the following as a standard for the breed: Comb square at front, tapering nicely into a long spike, full of points by no means plain, firmly and evenly set on the head; face, red; ear lobes, moderate size, round as possible, and clear white; legs, leaden-blue; carriage, graceful; plumage, very profuse. Cocks—Silver-spangled: Color, clear, silvery-white ground, every feather tipped or spangled, the breast as bold as possible, but showing the spangle, the bars of the wing regular and bold; neck, back, and saddle nicely tipped; bow well marked (by no means cloudy, brown, or brassy); back as green as possible. Golden-spangled: Color very black and rich, the back glossy green; the neck, back, and saddle nicely striped; bow of wing well marked. Hens—Silver-spangled: The white clear and silvery; the spangles large, green as possible, distinct, and clear. Golden-spangled: Ground, rich; clear spangles, large and distinct.

The feather markings of the penciled varieties differ greatly from those of the spangled; the latter being commonly called "moon-eyed" from the round or oval appearance of the spangles, while the markings of the penciled varieties are in parallel bars of reddish-bay or

black, or clear silvery-white and black, as the case may be. White and Black Hamburgs are solid white or solid black in plumage.

No standard weight is given for Hamburgs.

HOUDANS.

The three varieties of poultry in the French group are the Houdans, Crevecœurs, and La Fleche. Of these, the Houdans (fig. 123) are conceded to be the most popular and profitable, being bred to a great extent throughout the entire country. They are hardy and prolific layers of large, white eggs. For table purposes they are among the best fowls. They have small bones and the flesh is tender and delicious. The chicks are sprightly, active, and feather rapidly. They are nonsitters and light feeders; like the Leghorns, they may be fed at a small cost as compared with some of the larger breeds. They are of medium sized and of a mottled-white plumage, black and white intermixed, the black slightly predominating; wing bars and secondaries, black; primaries, black and white intermixed. Houdans are a crested variety, having a leaf comb, shaped somewhat like the letter V, which rests against the crest; crest of cock is large, well fitted upon the crown of the head, falling backward upon the neck, and composed of feathers similar in shape and texture to those of the hackle. The crest of the female is large, compact, and regular, inclining backward in an unbroken mass. A peculiarity of the breed is their having five toes, like the Dorkings; shanks and toes are of a pinkish-white color.

The standard weight of cocks is 7 pounds; hens, 6 pounds; cockerels, 6 pounds, and pullets, 5 pounds.

DORKINGS.

This English fowl is one which may be considered an ideal bird for general purposes. It is a hardy fowl and can stand almost any amount of cold weather, providing the ground is not damp. This is proved by the fact that it does well in the northern part of Scotland and in the extreme north of Ireland, among the Cumberland Hills, and in other places equally cold and exposed. It should be remembered by all who contemplate raising it, that the soil must not be damp if success is to be expected with it. The Dorking (fig. 124) is one of the oldest of domestic fowls, if not the oldest. There are no definite records to show when it first lived in England, or whence it came, but the supposition is that it was carried to England by the Romans, who appear to have possessed fowls of similar characteristics.

The chief distinctive mark of the breed is the presence of a fifth or supernumerary toe, springing behind, a little above the foot and below the spur. It has been sought by various writers to deprive Dorking of the honor of being the original and principal rearing place of this justly celebrated variety, and it is asserted that the true Dorking

fowls are raised at Horsham, Cuckfield, and other places in the Weald of Surrey, and that the ancient and superior white fowls from Dorking are a degenerate race compared with the improved Sussex breed. The feature in which this bird is most popular is its table qualities. The flesh is white and very delicate in texture. It is claimed by many to equal if not excel the French varieties. The broad, deep, and projecting breast of the Dorking admirably fits it for table purposes, and in this respect it is conceded by some to be the rival of the Indian Games. As layers the Dorkings are good, and are careful sitters and attentive mothers. In short, they are splendid fowls for the practical purposes of the farm.

There are three varieties of Dorkings: the White, Silver Gray, and Colored. The White Dorking is really the purest blooded of the three, as for years this was the only variety which invariably produced the fifth toe, although the Colored and Silver Gray varieties seldom fail to breed this peculiarity. In color the White Dorking is of clear, unblemished, glossy white. The comb and wattles are a bright-scarlet red; the legs are either white or a delicate flesh color.

Silver Gray Dorkings are beautiful in plumage. The head of the cock is silvery-white; hackle, pure silvery-white, free from stripes; comb, face, ear lobes, and wattles, bright red; beak, horn color or white; eye, orange; breast, thigh, and under parts, black; back, shoulder coverts, saddle, and wing bow, pure silvery-white; coverts, greenish-black; primaries, black, edged with white; secondaries, part of outer web forming wing bay, white; remainder of feathers forming wing butt, black; tail, greenish glossy black; legs, feet, and toe nails, white. The eye, beak, comb, face, wattles, legs, feet, and toe nails of the hen are the same as in the cock; head, silvery-white, with slight gray markings; hackle, silvery-white, clearly striped with black; breast, rich robin-red or salmon-red, shading off to gray in the lower parts; back, shoulder coverts, saddle, wing bow, and wing coverts, bright silver-gray, with minute pencilings of darker gray on each feather, the shafts of the feathers white; primaries, gray or black; secondaries, gray; tail, gray, of a darker shade than body; quill feathers, black.

Colored Dorkings differ from the others only in color, the general color of the male being black and straw color, while the female is marked with black and mixed gray, with breast of dark salmon edged with black. The combs of Dorkings differ in the three varieties; Whites have a rose comb, Silver Grays have single combs, and Colored Dorkings may have either single or rose combs, but single is preferred.

The standard weights for Dorkings vary. The weights for Whites are: Cocks, $7\frac{1}{2}$ pounds; hens, 6 pounds; cockerels, $6\frac{1}{2}$ pounds, and pullets, 5 pounds. Silver Grays: Cocks, 8 pounds; hens, $6\frac{1}{2}$ pounds; cockerels, 7 pounds, and pullets, $5\frac{1}{2}$ pounds. Colored: Cocks, 9 pounds; hens, 7 pounds; cockerels, 8 pounds, and pullets, 6 pounds.

CAMPINES.

Campines belong to the Hamburg class. They are an old breed, but have only recently been admitted to the standard. The earliest mention of them appears to have been in 1828, when they were referred to as a small variety of fowls imported from Holland, and called "Everyday hens," or "Everlasting layers." This name is still applied to them on their native soil. Campines are rated as extraordinary layers in Holland, their native country, but their introduction into the United States has been so recent that a comparison with the other egg-laying breeds can not be satisfactorily made. Those, however, who keep them speak highly of their laying qualities. They much resemble the Hamburgs, so much so that many think they are the same class of birds. They differ, however, from Hamburgs in the comb, the Campines having a single comb, while the comb of the Hamburg is rose. There are two varieties of Campines, the Golden and the Silver. The color of the Golden is a rich golden-bay in the neck plumage with a darker yellow for the body color. The Silver Campines are in color silvery-white and black throughout their plumage. The shanks and toes of both varieties are dark blue in color, wattles bright red, and ear lobes white or bluish-white.

No standard weight is given for Campines, but their average size is about the same as that of the Hamburgs.

ANDALUSIANS.

The Andalusian (fig. 125) is one of the prettiest fowls of the feathered race, being of a beautiful light and dark blue plumage. It is called the Blue Andalusian, and is the only variety of its class. It is not as popular in this country as it should be, owing to the sentiment against white skin and blue shanks. English and French poultrymen prefer these qualities in a bird, and with them it is very popular. Andalusians are nonsitters, and splendid layers of large white eggs, equaling in size those of the Minorca. The chicks are hardy, mature early, and pullets begin laying when five or six months old.

For farm purposes they are of the same class as the Leghorn and Minorca, the preference being only in the color of their plumage. For fancy purposes they are an ideal bird on account of their beauty. Their general characteristics are those of the Leghorn. In color the hackle and saddle feathers are dark blue, approaching black; breast, a lighter shade of blue, each feather having a well-defined lacing of a darker shade; body and fluff, similar in color to breast, but somewhat darker; primaries, light blue; secondaries and wing coverts, dark blue; wing bows, darker blue, approaching black; tail and sickle feathers, dark blue, approaching black; shanks and toes, slaty-blue.

No standard weight is given for Andalusians; their average size is that of the Leghorn.

METHODS OF PROPAGATING THE ORANGE AND OTHER CITRUS FRUITS.

By Herbert J. Webber,
Assistant, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

GENERAL REMARKS.

The methods used in propagating citrus trees do not materially differ from those used in the propagation of other fruit trees. However, there are certain differences with which the prospective grower of citrus trees should be familiar, and it is therefore the intention of the writer to briefly describe the principal methods employed by citrus nurserymen and growers in Florida as a guide for those not already familiar with the industry.

One of the most difficult questions the prospective orange grower must decide is whether to use seedling or budded trees. Such conflicting opinions exist among orange growers in Florida regarding this question that to decide the best policy is confusing and somewhat difficult. The pros and cons of the question, however, can not be discussed here. Suffice it to say that the general tendency of intelligent and progressive growers is to use only trees budded with thoroughly tested and approved varieties. Practically all the advance that has been made in improving citrus fruits by propagating from selected seedlings, hybrids, sports, etc., which produce superior or peculiar fruits, depends entirely upon propagation by budding and grafting, as the characteristic features are commonly lost by seed propagation. However, many continue to use seedling trees, and there will probably always be some used.

SEEDLING TREES.

When seedling trees are to be used, the selection of seed becomes an important feature. Any and every orange seed should not be used. On the contrary, the greatest care should be exercised in selection. It is not an uncommon report that seeds of sweet oranges frequently produce sour oranges, and vice versa, but this is probably never true unless the seeds are the result of hybridization. It is well recognized by growers in Florida, California, and Italy that when seeds of a sweet orange are planted, trees bearing sweet fruit, of a fairly good character, almost invariably result. Orange trees, however, are generally grown in close proximity to lemons, limes, sour

oranges, pomelos, etc., and it is not to be wondered at if hybridization occasionally occurs. When hybridized with the sour orange, lemon, etc., the resulting seedlings may naturally be expected to produce sour, unmarketable fruit, or fruit with rough and unsightly skin. While seedlings of the sweet orange almost invariably produce sweet fruit similar to that produced by the parent, there is nevertheless considerable variation wholly aside from that resulting from crossing and hybridizing. This uncertainty as to fruits, especially the finer sorts, reproducing themselves true to seed is what renders budding and grafting desirable in the orange as in other fruit industries.

Where sweet seedlings, or in fact any kind of seedlings, are to be grown, the seeds should be taken from selected seedling trees known to produce good fruit and which are isolated from citrus trees of other varieties or species. Such selection would prevent the probability of obtaining seeds affected by crossing or hybridizing with other varieties, and make it reasonably sure that seedling trees producing good fruit would be obtained. Pomelos, lemons, limes, citrons, kumquats, and the various other species of citrus fruits are almost invariably produced true by the seed, as in the case of the orange, that is, pomelos produce pomelos, lemons produce lemons, etc. Like other fruit trees, however, the different varieties of the fruits named do not reproduce themselves true from the seed. Seedling pomelo, or grape-fruit, trees are quite common in Florida. The varieties, however, have not been so much improved as in the case of the orange, and as yet there is but little difference between the fruit of seedlings and that of the best named varieties. The principal varieties or subspecies of mandarin oranges cultivated in Florida, known as the China (commonly called Mandarin), Tangerine, King, and Satsuma, are not infrequently propagated by the seed, and with but slight variation they commonly reproduce true to the parent variety. However, they seldom average equal in flavor to the selected varieties, which must be budded, as they are not reproduced true by the seed. Seedlings of the China are said to show a tendency to form an elongation of the rind at the stem, which makes them awkward to pack. In all cases where seedlings are to be used the greatest care should be exercised to select seed from isolated trees known to uniformly produce good fruit.

THE SEED BED.

The seeds used for planting should in all cases be selected from fully grown, normal fruit taken from vigorous, healthy trees. In this case, as in others, it is important that the seed should be good in order to secure vigorous seedlings. The method of extracting the seeds from the fruit most commonly followed by nurserymen and those planting on an extensive scale is to cut the orange in half and squeeze the

seeds out into a receptacle. Sometimes the entire fruits are thrown into barrels and allowed to decay, after which the seeds are separated by washing in a coarse sieve, which allows the pulp to pass through. The seeds should be planted immediately, before they have had time to dry, but if this can not be done they may be preserved moist and in good condition for some time by packing in damp earth. If seeds dry out from necessity or by accident, the great majority of them can be induced to germinate by soaking in water for several days previous to planting.

Many different plans are followed in arranging the seed bed. If only a few seedlings are to be grown, the seeds may be planted in boxes about 8 inches or 1 foot deep and of any convenient size. The soil should be kept moist, but not wet. Mulching the soil with moss (the common Florida long moss) until the plants appear is said by some to be beneficial. If many seedlings are to be grown, it will probably be necessary to plant them in the open ground. In such cases the seeds are commonly sown in beds from 3 to 4 feet wide and about 2 feet apart. Sufficient room must be left between the beds so that the seedlings may be easily cultivated. The seeds are spread broadcast or are sown in drills, 1 or 2 inches being left between each seed. They are then covered with soil to a depth of about 1 inch. Some sow the seeds from one-half to 1 inch apart in rows about 1 foot apart.

After planting, the seed bed must be either mulched or covered with a shelter of some kind to protect the young seedlings from the sun when they first appear. The cover may be made of brush supported by a suitable frame, or of some thin cloth, like cheese cloth or burlap, such as is used in making fertilizer sacks. The practice of protecting the bed with some such cover is more commonly followed than mulching, and is apparently the preferable method. January is probably the best month for planting, although any time will do if care is taken to keep the seeds moist. If planted late in the spring, the dry season in April and May comes before they are thoroughly rooted and is liable to seriously injure them, so that watering may be required. Seeds planted in boxes usually appear in from ten to twenty days, but when planted in open beds they do not appear for about six weeks, although less time may elapse if the beds are artificially watered. The success of the seed bed depends very largely upon cultivation and fertilization.

Previous to planting, the soil should be fertilized with some non-heating manure, such as well-rotted stable manure or some of the commercial manures for vegetables. Heating manures, like blood and bone or cotton-seed meal, should be avoided, as they are liable to injure the young seedlings. The soil should be fertilized a second time when the plants are from 4 to 5 inches in height, and probably again a third time before they are removed to the nursery. Cultivation should be very thorough, as in the case of vegetables, no weeds being allowed to grow.

The seedlings may be left in the seed bed for a year or more, until they are about the size of a lead pencil at the collar and from 12 to 14 inches in height. Probably the best time to transplant to the nursery is in December or January, when the plants are thoroughly dormant. Usually transplanting can be done with safety at any time during the rainy season, but even then it is necessary that the soil should be thoroughly wetted, either naturally or artificially, several times shortly after planting, if the seedlings are to succeed well.

In digging the seedlings, carefully thrust a spade down perpendicularly near the plants and work it back and forth until the soil is loosened from the roots, after which the plants may be lifted out without injury. The roots and tops are then pruned preparatory to planting, the tap-root being cut off to about 8 or 10 inches in length and the tops pruned back a corresponding distance. A number of the seedlings may be taken in the hand and the roots and tops cut off with an ax to the desired length. As the seedlings are removed from the bed the roots should be placed in water or wrapped in damp moss or cloth to prevent them from drying out while they are being transferred to the nursery and planted. All small or weak seedlings should be discarded.

THE USE OF CUTTINGS.

Lemons, citrons, and limes are sometimes propagated by cuttings. Oranges and pomelos may also be propagated in this way, but as they do not root readily this method is seldom used with these fruits. As in other cases, the cuttings are taken from young wood, the twigs being cut into sections from 4 to 6 inches in length, and usually with a portion of one or two leaves remaining attached to the upper end. The base of the cutting is prepared by a smooth, slanting cut made with a sharp knife (a smoothly cut surface forms roots much more readily than a roughly cut surface in which the tissue is injured). Cuttings thus prepared may be planted in any convenient-sized box filled with sand. The basal end of the cutting is inserted in the soil, leaving about 1 inch of the upper end exposed. Wherever bottom heat can be secured, rooting is greatly facilitated. When the cuttings have sprouted and have attained a height of 8 inches to 1 foot, they may be transplanted to the nursery, as in the case of seedlings.

THE NURSERY.

The citrus nursery should be on well-drained soil and in a locality as thoroughly protected from frost as possible. Young trees are much more easily affected by frost than old ones. Wherever possible it is advantageous to have the nursery located on the south side of a considerable body of water, which serves to warm the atmosphere. The land should be thoroughly cultivated and all rubbish removed. The trees are usually planted in rows from 4 to 5 feet apart. The

tendency of nurserymen is to put the rows a considerable distance apart to facilitate budding and cultivation. The seedlings are planted from 14 to 15 inches apart in the rows. As it is much easier to cultivate straight rows than crooked ones, considerable care should be exercised in laying out the nursery (fig. 126). During the process of planting, the seedlings should be kept with their roots in water or wrapped in wet cloth to protect them against drying out. The holes in which the seedlings are to be planted are commonly made by thrusting a spade into the ground and pressing it back and forth until the soil is sufficiently spread. The seedling may then be put in place and the soil pressed firmly around it. The holes in which to set the seedlings may also be made by pressing a nurseryman's dibble

FIG. 126.—Citrus nursery at Eustis, Fla., showing method of arranging and staking the trees (photographed October 23, 1896).

into the soil and crowding it back and forth until a space of the desired size is made. The roots may then be spread out and the soil pressed firmly around them. In planting great care should be exercised to get the soil packed firmly around the base of the root and not simply around the collar.

Wherever convenient, it is desirable to use water in planting. The soil must always be moist when seedlings are transplanted, and therefore transplanting should be done soon after a heavy rain, or else the ground should be artificially watered. This is very desirable, not only for the benefit to the plants, but if the soil is dry it is difficult to keep the holes open properly and prevent the dry, hot sand from falling in around the roots. Cuttings are transplanted in the same way as seedlings.

In the nursery, as in the seed bed, thorough cultivation and heavy fertilization insure success. In fertilizing, chemical manures especially prepared for vegetables should be used. About 2,000 pounds per acre of such fertilizer should be given annually in two or three applications. If two applications are to be made, one in February and one in July will probably give the best results. In case of three applications, February, June, and August will prove satisfactory periods.

The trees are allowed to remain in the nursery about two years before transplanting into the grove. The second spring after planting in the nursery they have usually attained sufficient size for budding. If it is intended to bud them, they should all be budded at this time, as it is desirable to insert the buds as soon as the trees have attained sufficient size, in order to throw all growth into the bud. If they are budded in the spring, the buds will have reached sufficient size by fall for the trees to be transplanted into the grove or put on the market, as may be preferred.

STOCKS.

The kind of stock used for budding has considerable influence on the health, vigor, and productiveness of the tree. As some stocks will not do well on certain soils and some varieties grow well only on certain stocks, it is desirable that the stock used for planting any given tract be carefully considered. The orange and pomelo, or grape fruit, are commonly budded on sweet-orange, sour-orange, lemon, or pomelo stock. If planting is to be done on rich, moist lowlands (low hammocks and flat woods) which are subject to foot rot, or mal-di-gomma, stock which is immune from this disease should be used. Sour-orange stock is the most resistant variety that has been found and usually gives the best results. Pomelo, or grape-fruit, stock is also quite resistant and is probably the best stock in foot-rot regions where the soil is droughty at certain seasons of the year. It is a more vigorous grower than the sour-orange and resists drought better. Foot rot is common also on some flat woods and high pineland soils which are dry and well drained, and in such localities the pomelo is probably the best stock for general use.

In the case of high and dry lands not much subject to foot rot, sweet orange, lemon, and pomelo are probably the best stocks. On dry lands, sour stock, although much used, does not always give satisfaction. Lemon stock, particularly the Florida rough lemon, is a very excellent stock for dry, sterile lands, as it is a very vigorous grower, doing fairly well in soil where the sweet-orange would perish. It is so easily injured by cold, however, that it is safe only in southern localities. Pomelo is also a more vigorous grower than sweet orange and is probably a better stock for dry lands, but it is more tender and should be budded near the ground or its use limited to southern regions. In regions where foot rot is prevalent, sweet-orange stock and lemon stock

should never be used, as they are particularly subject to this disease. The lime, which is a very vigorous-growing stock, similar to the lemon, is used to some extent in southern Florida as a stock for the orange, and is said to be excellent for barren scrub land and rocky locations. The hardy trifoliate orange is used to a limited extent as a stock for the orange, but has not always given thoroughly satisfactory results.

Tangerine and China (Mandarin) do well on any of the stocks used for the common sweet orange, but as the grower usually desires to increase the size of these varieties it is probably preferable to bud them on rough-lemon stock. The Satsuma, which is a hardy variety, is very extensively budded on the hardy trifoliate orange, on which it is said to do well. It also gives good results on sweet-orange, which is probably the best stock to use in southern locations, but does not do well on sour-orange stock. Lemons are usually budded on rough-lemon, sour-orange, or sweet-orange stock, the rough-lemon being considered the most desirable, as it is the most vigorous grower. In places where foot rot abounds, sour-orange stock should be used.

In selecting stocks it is also important that the latitude and local climate be carefully considered. The various citrus species used as stocks for grafting or budding vary greatly in their resistance to cold. The following is a list of stocks commonly or sometimes used, and is arranged in order of hardiness, the hardiest being placed first: Trifoliate orange, sour-orange, bitter-sweet orange, sweet-orange, pomelo, rough-lemon (or lemon), lime, and citron. In localities where there is danger of severe freezes, no matter what stock is used, the point of union should be placed near or below the surface of the soil, so that the buds may be saved in case of freezes.

In regard to the effect of stock on the character of the fruit, it may be said that while some growers claim to have observed that the fruit is rendered coarser and thicker skinned by budding on vigorous, rapidly growing stocks, like the pomelo and the lemon, yet it is certain that the difference is very slight and in most cases hardly perceptible. In this connection all that needs to be considered is that stocks of this nature tend to produce rather larger fruits. While in some varieties this character is a disadvantage, it is, on the other hand, an advantage to have a vigorous stock, as in certain varieties this is necessary to insure fruitfulness. The varieties of the Navel orange are unfruitful on sweet or sour stock, but usually they are normally prolific if budded on rough-lemon.

BUDDING.

WHEN TO BUD.

The trees in the nursery should be budded when they have attained a size of from one-half to one inch in diameter. If the trees are grown for sale it is probably best to wait until they are three-fourths to one inch in diameter before budding. If the young trees

are grown for planting, it may be desirable to bud them rather sooner, in order to put them as soon as possible in their permanent places in the grove. If a tree is transplanted when still small, the greater portion of the roots and top is saved, and the shock in transplanting is therefore less. Budding can be done only when the tree is in a growing condition, so that the bark slips and separates easily from the wood. It is usually preferable to bud as early in the spring as possible. The nursery is commonly budded during March and April. It may be gone over again in May and those stocks which failed the first time rebudded. Budding may be done at any time during the summer, unless the trees are checked in growth by a severe drought, but it is usually not best to bud later than the first of July, as sufficient time should remain for the bud to push and mature the wood of the first growth before winter. If the budding can not be done by the time named, it is probably best to wait and put in dormant buds in October or November.

FIG. 127.—Sweet-orange twigs: *a*, round twig of select buds; *b*, angular twig of buds.

SELECTION OF BUDS.

Bud wood should always be selected from fairly well-matured wood of the current year's growth. Round sticks (or as nearly round as possible) should be selected. The young growth of orange wood is at first angular, becoming rounder as the twig matures. The basal portions of the young branches, which are nearly or quite round (fig. 127, *a*), supply the best buds, with the exception of the first two or three, which are usually somewhat imperfect and should be discarded. Where it is difficult to secure well-rounded wood, angular wood which is not too soft (fig. 127, *b*) may be used. This, however, is not quite so satisfactory. Thorny bud wood should never be used when other wood can be obtained. Thorny trees are very undesirable, and a careful selection of thornless bud wood will soon result in thornless trees. The thorns have been bred out of many of the best citrus varieties, and if nurserymen would exercise proper care all the desirable varieties could soon be rendered thornless.

The bud wood should be cut while the wood is dormant, before the buds show any signs of pushing. That desired for spring budding should be cut the latter part of January. It is well to leave the wood on the tree as long as possible, and therefore the trees should be carefully observed during this period. When the first buds are observed to be swelling, all the bud wood desired should be cut immediately. After cutting, the leaves should be pruned off and the twigs cut into sections of the desired length. To preserve the bud wood until needed, the twigs should be tied up in convenient-sized

bundles, carefully labeled, and packed in old sawdust in a box of suitable size. The box should then be closed and buried in sheltered ground several inches below the surface. In this way bud wood can be preserved in good condition for from two to three months. Dampened sphagnum, or peat moss, may be used instead of sawdust, but in this case considerable care must be exercised to get the moss properly dried. It must be moist, but not wet, for if too wet the bud wood may mold. The same caution applies also to sawdust. In this case, the proper degree of moisture can be secured by taking the material from the interior of an old pile. Sawdust does not lose its moisture readily and is the best material for packing. Some simply bury the bud wood in the soil under shelter, digging down until the moist earth is reached.

MATERIALS.

Before beginning the operation of budding, material should be provided for wrapping the buds. For this purpose cotton cord, yarn, strips of waxed cloth, etc., are used. The last named has practically superseded all others in Florida, being more convenient and giving better results than any other wrapping material. The strips are made from strong muslin or calico. Before the cloth is torn into strips, it is folded into convenient size and dipped into a hot solution of wax made by melting together two parts of beeswax and one part of resin. Several formulas for making this wax are used, any one of which will probably answer. The method described is known from personal experience and observation to give good results. After saturating the cloth with the hot wax, all the superfluous wax should be removed before the cloth cools. To accomplish this quickly hang the piece of cloth, folded in convenient form before waxing, over a small, strong stick (fig. 128, *a*), which is held by an assistant. Then take two similar sticks of wood and holding them parallel on either side of the cloth (fig. 128, *b*), press them firmly together and pull downward, squeezing out the superfluous hot wax. The cloth should then be spread out until cool, after which it is ready to be torn into strips of the desired size, that is, one-fourth to one-half inch wide and from 10 to 12 inches long. The cloth may be torn into strips before it is taken into the field, or it may simply be torn into convenient-sized pieces and afterwards torn into strips in the field as desired for use. The latter is probably the most convenient way. Using waxed cloth for wrapping effectually excludes moisture, prevents the bud from drying out, and the work can be done more quickly than with string, as the strips cover more surface and do not require tying, the wax serving to hold the cloth firmly in place. It may therefore be recommended as far preferable to any other wrapping material.

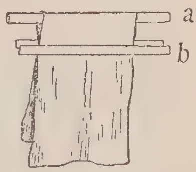

FIG. 128. Method of removing wax from budding cloth.

HOW TO BUD.

Budding is a simple process, consisting in inserting a bud of a desired variety under the bark of the stock in such a way that the freshly cut inner bark of the bud comes in close contact with the layer of growing wood (cambium) of the stock. The bark is closed over the inserted bud and the stock wrapped with waxed cloth, as described, so that the bud is firmly pressed against the growing wood. If the operation is properly performed, the tissue of the bud and stock soon fuse together and the bud may be forced to grow.

In all varieties and stocks of citrus fruits the process of budding is practically the same, the method commonly employed being that known as shield, or eye, budding (fig. 129). The bud is inserted in the young stock near the ground. Previous to the severe freezes of the winter of 1894–95 the general practice was to insert the buds 12 to 18 inches above the ground, but since then the tendency is to bud as near the surface of the soil as possible, so that the trees may be readily banked with the earth above the bud to protect against injury from freezes. Most of the buds are now inserted from 2 to 6 inches above the soil. In sections where foot rot is abundant and sour-orange stock is used as a preventive measure the buds should be inserted from 12 to 18 inches above the soil, so that the sweet-orange wood will be above the influence of the disease.

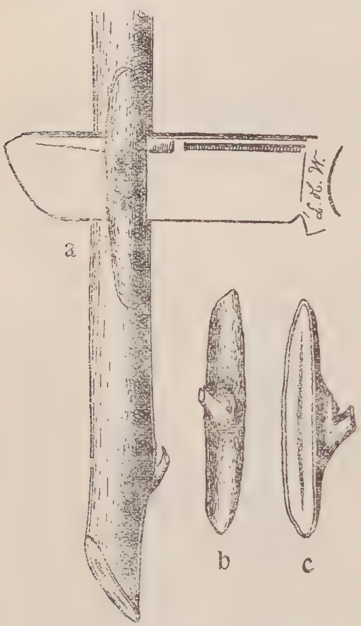

FIG. 129.—Shield, or eye, budding: *a*, method of cutting bud from round twig; *b*, bud cut ready to insert; *c*, face of bud showing the cut surface.

All leaves and limbs which would hinder the proper wrapping of the buds should be cut away with a sharp budding knife. The use of sharp tools is the secret of success. A vertical cut about $1\frac{1}{2}$ inches long is made at the point where the bud is to be inserted. At the base of this a horizontal cut is made, so that the two cuts present the appearance of an inverted T (⊥), as shown in fig. 130, *a*. The cuts should not be deep. The aim should be to merely cut through the bark, but no injury will result if the cuts are rather deeper. The lower edges of the bark are slightly raised with the end of the knife blade (fig. 130, *b*) to facilitate the insertion of the bud. This may also be accomplished by giving the knife an upward turn after making the horizontal cut. Now, take a stick of bud wood in the left hand and cut out a bud, as illustrated in fig. 129. Formerly the portion of the wood cut out with the bud was removed, but experience

has shown that this is entirely unnecessary. The upper end of the bud is inserted under the slightly raised ends of the bark (fig. 130, *c*) and gradually pushed upward until all portions of the cut face of the bud come in contact with the wood of the stock (fig. 130, *d*). If in proper condition for budding, the bark of the stock readily separates, allowing the bud to be pushed upward into position. The bud is now ready to wrap. Take a strip of the waxed cloth prepared as above, and beginning slightly below the horizontal cut wrap tightly around the stock over the bud in a spiral manner, each turn slightly overlapping the previous one. The wax holds the cloth in place and makes it possible to draw it very tight. When the vertical incision has been entirely covered, turn the end of the strip slightly downward over the wrapped portion, to which it adheres more firmly than it would to the bark, and no tying will be necessary (fig. 130, *e*). It

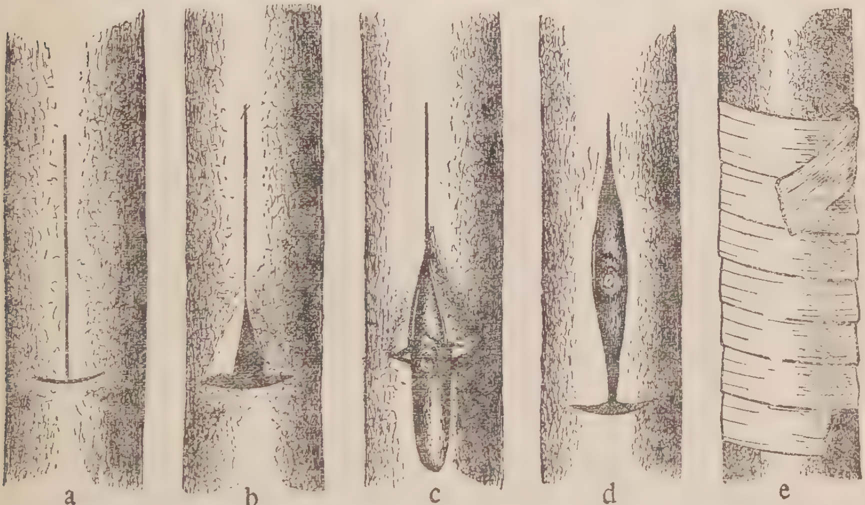

FIG. 130.—Shield, or eye, budding: *a*, incision on stock; *b*, incision with lower ends of bark raised for inserting the bud; *c*, bud partially inserted; *d*, bud inserted ready to wrap; *e*, bud wrapped with waxed cloth.

is better to wrap from below upward, as in this case each turn overlaps the other in the right direction to prevent water running down the stem from entering. Nurserymen usually wrap over the bud, covering it entirely. Some, following the practice commonly used in other fruits, leave the eye of the bud exposed. This, however, is more troublesome and does not succeed so well.

In some cases where bud wood of certain varieties is difficult to secure, it may be desired to use buds from the young angular wood (fig. 127, *b*). This may be used with good results if the stock to be budded is growing rapidly and is in a succulent condition. In this case the method of cutting and inserting the bud is slightly different from that already described. In cutting the buds the stick is turned slightly to one side, so that as the bud is cut off the eye lies on one side instead

of in the center of the bud (fig. 131, *a*, *b*, and *c*). It is only by cutting the bud in this way that the cut surface is made wide enough to hold the bud firmly in position. For inserting these buds an incision is made in the bark, as shown in fig. 130, *a*. The bark is slightly raised on one side with the point of the knife and the bud is slipped under in a lateral direction, the eye remaining in the vertical slit (fig. 131, *d*). The bud is then wrapped as shown in fig. 130, *e*.

UNWRAPPING THE BUDS.

In from ten to twelve days the buds will have united with the stock and may then be unwrapped. In early spring, when the weather is cool and the growth slow, the wrapping should be left on from fifteen to twenty days, while in the summer, when the weather is warm and the growth rapid, ten days is usually a sufficient length of time. However, it is impossible to say definitely how much time should elapse before the wrapping should be removed, as the wood of the stock should never be allowed to grow over the buds. It should not be removed until a light grayish line of new tissue can be seen forming around the edge of the incision made in inserting the bud. A little experience will enable one to tell at what stage it is safe to unwrap. Under ordinary conditions from twelve to fifteen days will give good results, but in very dry weather in the summer, when growth is slow, it may be necessary to leave the wrapping on for a longer time. Some ten days after budding an examination should be made of a number of the buds, and if they are found to be well healed on, the wrapping may be taken off, but if not, the wrapping should be replaced and allowed to remain some time longer. If the wraps are allowed to remain too long, the wood of the stock is liable to grow over the buds and greatly hinder their pushing.

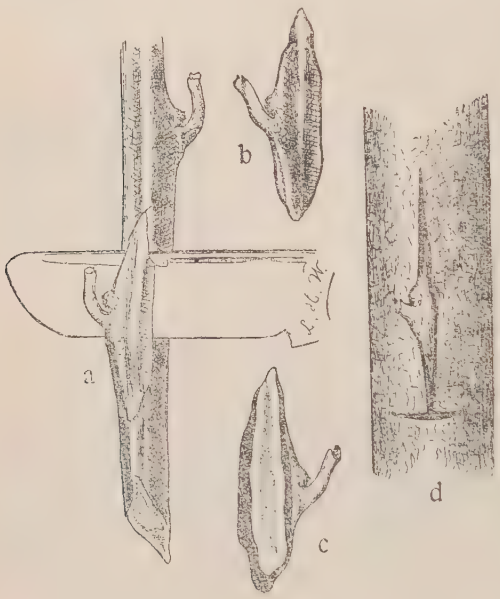

FIG. 131.—Shield budding with angular wood: *a*, cutting the bud; *b*, bud cut ready to insert; *c*, bud showing cut face; *d*, bud inserted, bark on right side only being raised.

FORCING THE BUDS.

In order to force the buds to push uniformly after they have healed on, it is necessary to severely check the growth of the stock. This is

most commonly accomplished in nursery trees by lopping the tops, as it is called, which is usually done from three to five days after the wraps are removed from the buds. The lopping is usually done with pruning scissors, the knife edge being placed about 2 inches above the bud and the stock cut two-thirds through. The top is then bent over to one side and allowed to rest on the ground (fig. 132, *a*).

FIG. 132.—Treatment of buds: *a*, young tree lopped to force bud; *b*, bud and supporting stake after "lop" has been removed.

To provide for subsequent cultivation and attention it is necessary to use some definite plan of budding and lopping in the nursery. Two methods most commonly followed by Florida nurserymen are to lop the tops of two adjoining rows into the same center (fig. 133, *a*), keeping the alternate centers free for cultivation, or to lop the tops of alternate rows in different directions, one row in each center (fig. 133, *b*), and place them near the rows. By the latter method a cultivator may be run up one row and down the other, passing always in the direction in which the tops are inclined so that the branches will not interfere with the cultivator. Usually the old tops are allowed to remain attached until the buds have attained a height of from 12 to 18 inches, after which they may be cut off.

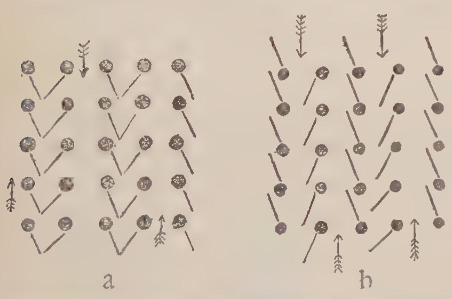

FIG. 133.—Diagrams illustrating methods of lopping nursery trees: *a*, lopping two rows in one center, leaving alternate centers free for cultivation; *b*, lopping alternate rows in opposite directions.

Some nurserymen have found that the buds make a larger growth if the old tops are allowed to remain attached through the summer and are cut off in September. If this practice is followed, two rows of trees should be lopped together. The tops thus form a dense shade or sort of mulch on the soil, keeping it moist and preventing the weeds from growing. In this case it is also desirable that the rows lopped together should be planted rather close (about 3 feet apart), for if this is not done the weeds will grow up among the tops, making it necessary to cut off the latter when the buds are 1 foot to 18 inches high in order to keep the weeds down.

In the case of vigorous-growing stocks, like the rough-lemon, it is said to be very desirable to leave the tops attached for some time.

When the old tops are removed, the portion remaining above the bud should be cut off smooth and close to the bud, so that it will soon heal over without forming an ugly scar (fig. 132, *b*). Some follow the practice of coating the freshly cut end with shellac, but others working on an extensive scale never do this. It is seldom that any noticeable benefit is derived from the practice.

GROWTH OF THE BUDS.

The attachment of the rapidly growing bud is at first very weak and it is necessary to strengthen it by tying to a stake (fig. 132, *b*). Some nurserymen practice cutting the stock rather high in lopping, and support the buds for a time by tying them to the remaining portion of the stock. The buds push much better, however, when the stocks are cut very close in lopping, so that it is hardly desirable to depend upon this method of supporting the buds, as in either case it is necessary later to supply the supporting stakes.

The development of the buds should be carefully watched during summer, and they should be pruned in such a way as to produce a top of the desired shape. In Florida, where a low tree is desired, it is necessary to nip the tops when they are 2 or 3 feet high to induce branching. The buds which push low down on the stock or bud should be rubbed off before they have grown to any size, as their growth detracts from the development of the bud.

The best time for transplanting orange or other citrus trees is probably during December, although they may be transplanted in January or February or during the rainy season. By December buds put in early in the spring have reached a convenient size for transplanting into the grove.

DORMANT BUDDING.

Putting in buds which are intended to remain dormant during the winter, or dormant budding, as it is called, is usually done in October or November. The process is exactly the same as described above, except that the tops are allowed to remain standing until the following spring. They are lopped in the usual manner the latter part of February, or just before the spring growth starts. The advantage of dormant budding is to secure the first spring growth in the bud, which is the largest growth of the year.

SPRIG BUDDING.

This is a form of budding frequently used on old stocks, where the bark is thick, in changing the variety or replacing a limb accidentally broken off. A scion about 4 inches long is selected (fig. 134, *a*), and the basal end sharpened by a slanting cut on one side, as shown in the

figure. A curved oblique incision is made in the bark, the lower edge of which is slightly raised with the point of the knife, and the end of the scion inserted and pushed between the bark and wood in an oblique direction until the freshly cut surface of the scion comes in contact with the growing wood of the stock (fig. 134, *b*). The scion is held firmly in place by the bark of the stock, and the use of grafting wax or wrapping of any kind is said, therefore, to be unnecessary.

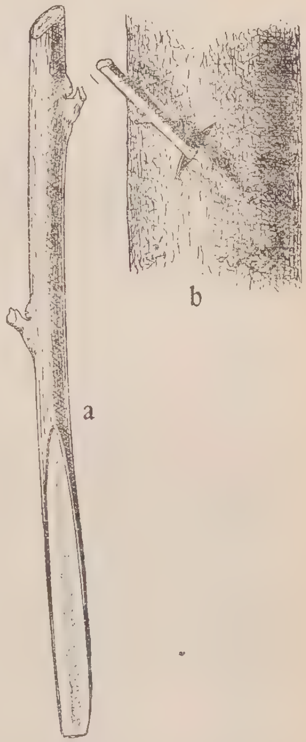

FIG. 134.—Sprig budding: *a*, scion; *b*, scion inserted in stock.

GRAFTING.

Grafting has not been extensively used in citrus culture in Florida, but as there is an increasing tendency to place the point of union between stock and graft, or bud, near or below the surface of the soil, this method will probably be more used in the future. There seems to be no good reason why it should not be adopted wherever desirable. Grafting should be done in January or February, while the trees are still in a dormant condition. The scions must be taken from thoroughly mature wood of the last season's growth. Round and thornless twigs should be selected if possible, although the somewhat angular wood may be used if thoroughly mature.

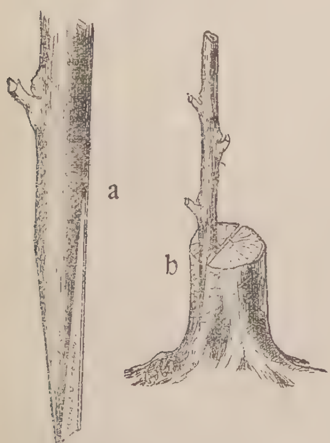

FIG. 135.—Cleft grafting: *a*, base of scion; *b*, stock showing central cleft with scion inserted.

CLEFT GRAFTING.

Cleft grafting, which is one of the simplest methods, may be used to advantage in place of budding in nursery trees where it is desired to place the point of union below the soil. A scion about 5 inches long is selected and the lower end sharpened to a wedge shape by two slanting cuts $1\frac{1}{4}$ inches long on opposite sides (fig. 135, *a*). The young stock to be grafted is cut or sawed off slightly below the surface of the soil and a cleft made in the stock (fig. 135, *b*). If the stock is larger than the scion, the latter must be inserted at the side, so that its cambium layer (the growing layer between the bark and the

wood) on one side will come in contact with that of the stock. After the scion has been pushed down into place, the stock should be wrapped with strips of waxed cloth, like those used in budding, one or more strips being put across the top of the stock to keep the sand out of the cleft until the graft starts to grow. The moist soil is then thrown up around the graft, leaving only the upper end exposed. The wrapping cloth will decay in a short time, but it is probably best to remove it soon after the grafts begin to grow.

TONGUE, OR WHIP, GRAFTING.

In grafting small stocks the tongue, or whip, graft (fig. 136) is generally used. If properly made, the tongue serves to hold the scion firmly in place and forms a good union. After the scion and stock are placed together, they are firmly wrapped around the point of union with strips of waxed cloth, as in the case of buds (fig. 130, *e*). The wrapping should be left on until the graft has started well, when it should be removed. By removing the soil somewhat around the collar the tongue graft may be used on small nursery trees to place the union below the surface.

FIG. 136.—Tongue, or whip, grafting: *a*, method of cutting stock and scion; *b*, stock with scion inserted.

CROWN GRAFTING.

When the tops of comparatively large trees (3 inches or more in diameter) are killed to the ground by freezing or in any other way which leaves the roots uninjured, they can be most quickly replaced by crown grafting. This method of grafting may be used to advantage on large limbs also. In crown grafting, as practiced in Florida, a scion about 5 inches in length is sharpened at the basal end by a long, slanting cut on one side (fig. 137, *a*). In crown grafting other fruits a slight shoulder is usually left on the scion, and this rests on the stock when the scion is inserted. When frozen or killed down, the stock to be grafted is sawed or cut off 2 or 3 inches below the surface of the soil, where the wood is fresh and living. With the aid of a knife blade the bark is then slightly loosened from the wood at one place and the scion is pressed in between the bark and wood, with the cut surface against the latter. The best places to insert the scions are in the concave portions of the trunk, as here, in order to allow their insertion (fig. 137, *b*), the bark can be pressed out without breaking. Several scions may be inserted on one trunk if desired. The bark, if unbroken, will hold the scion firmly against the wood and no wrapping will be required. If, however, it should

be necessary to split the bark to allow the insertion of the scion, it should be wrapped with string or waxed cloth to hold it firmly in position. Moist earth is then banked up over the stump until only the upper portion of the scion remains exposed. In using crown grafts above the soil, strips of waxed cloth or grafting wax must be used to prevent the scions from drying out.

ROOT GRAFTING.

Propagating citrus fruits by root grafting has never been thoroughly tested, so far as the writer is informed. In March, 1895, the writer was led to make several tests of this method, which, owing to the condition of some of the roots used, though not thoroughly satisfactory, yet strongly indicated that the method might frequently be used to advantage. About the first of April lateral roots, varying from one-half to three-fourths of an inch in diameter, were taken from sweet-orange trees and cut into sections about one foot in length, each having a fair quantity of fibrous roots remaining uninjured. These were immediately tongue grafted (fig. 136) with dormant sweet-orange scions obtained from California, and were then planted, the union being placed slightly below the soil. The majority of the grafts started growth promptly, but about one-half of these made very slow progress, the growth appearing unhealthy. The roots used were taken from trees about sixteen years old which had been frozen to the ground two months before, and this, it is thought, affected the results. While not recommending the general use of this method, the writer would suggest that the results obtained indicate that a bearing grafted tree may be secured in this way in far shorter time than by any method now practiced. The method would seem particularly promising where lemon, lime, or pomelo stocks, which root easily, are used.

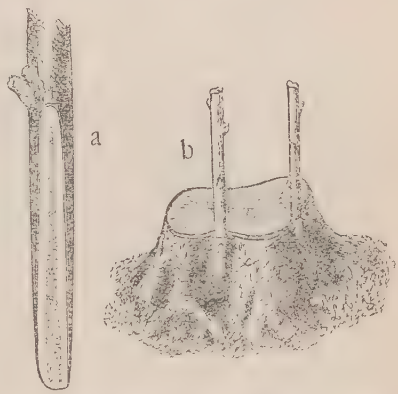

FIG. 137. Crown grafting: *a*, base of scion; *b*, old stock with scions inserted.

All the methods of budding and grafting described may be greatly changed in detail. No attempt has been made to describe all variations, only those methods being given which have proved most satisfactory and which are most commonly used.

INARCHING.

Inarching consists of uniting limbs of the same or different trees by a process similar to budding. Several methods of inarching are used, but only the one in most common use will be described. The two

limbs to be inarched must be close together, in such a position that one may be easily bent over against the other. The operation is practicable only where one of the limbs is comparatively small—under 1 inch in diameter. The small limb is cut off by a slanting stroke in such a place that the cut surface faces the other limb when bent over against it at the point where the union is to be made (fig. 138, *a*). A vertical and a cross cut, like an inverted T (⊥), is made in the bark of the large limb or stock at the point where the two limbs touch (fig. 138, *b*). The end of the small limb is then pushed up into the slit (fig. 138, *c*), as in shield budding described elsewhere, and strips of waxed cloth are wound around the union to hold the limbs firmly in place. The wrapping should be allowed to remain for a month or more, till the limbs have become very firmly grown together. Inarching is frequently used in cases where trees are girdled by foot rot, wood lice, or white ants (Termites), or in any other way. In foot rot, young sour-orange stocks, which are immune from this disease, may be planted by the side of trees in the first stages of the malady and inarched into them 1½ or 2 feet above the ground. In this way they may almost certainly be saved from the disease. If the bark of the diseased tree will not slip, a wedge-like union, similar to the cleft graft, should be tried, the incision in the stock being made with a chisel. In case of girdling by white ants or animals, sprouts from the roots may be inarched, or small trees may be planted by the side of the injured tree and inarched, as in the case of foot rot. Inarching is also frequently employed where it is desired to throw the strength of two or more sprouts into the development of one top, as in the case of numerous sprouts coming up around large frozen trunks. Limbs may be braced and strengthened by binding them together by means of inarching branches.

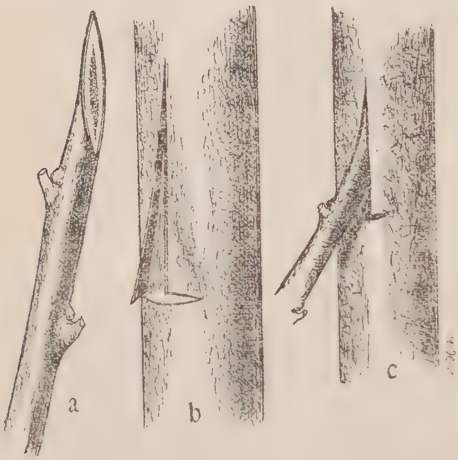

FIG. 138.—Inarching: *a*, end of limb to be inarched, showing form of slanting cut; *b*, incision on stock, with bark raised preparatory to inserting end of limb; *c*, limb inserted, ready to wrap.

IMPROVEMENTS IN WHEAT CULTURE.

By Mark Alfred Carleton,

Assistant, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture.

GENERAL REMARKS.

There is probably no agricultural product more variable as to supply and demand, and consequently more subject to variation in price, than wheat. It may bring a high price for one or two seasons and then fall greatly in value for several years in succession. These fluctuations are due to a number of causes, among which may be mentioned: (1) The fact that the natural wheat regions are, above all others, subject to extreme changes of climate, intermingled with seasons of prolonged and severe droughts being occasionally shorter seasons of too-abundant rainfall, all tending to make wide variations in the wheat harvest; (2) a rise in price causes the crop to be planted more extensively, and as a consequence the supply is increased and the price goes down; (3) war may increase the foreign demand; (4) a greater market is sometimes opened in foreign countries by commercial treaties which reduce or abolish the tariff on wheat or flour imported into these countries; (5) an unusual demand for feed for stock will necessarily increase the acreage devoted to the growth of other cereals, especially corn, and proportionally lessen the acreage in wheat; (6) feeding wheat to stock, as was done over a year ago in the West, may materially lessen the surplus of wheat on hand; (7) settlements in new countries often greatly increase the acreage given to wheat.

Some of these causes of variability in the profits to be derived from wheat raising can not be overcome merely by adherence to correct principles of agricultural science. There are, however, various instances in which there is room for an improvement in agricultural practice that would, without any question, make wheat culture much more profitable than it is at present. Indeed, during the recent period of low prices the uncertainty of yield and the inferior quality of the product had probably more to do with restricting profits than the actual decrease in price itself. Investigations made by the writer in the wheat districts of the Great Plains show that in some places an average of even 15 bushels of wheat per acre, at 40 cents per bushel, may be profitable.

METHODS OF TILLAGE.

With wheat, as with many other crops, the proper treatment of the soil may be considered half the battle. In wheat growing a great deal depends upon local conditions of soil and climate, and as these conditions in any particular locality can be thoroughly understood only by long residence in that locality the experiment stations in the several States should be able to give the most reliable advice relative to the adaptability of wheat to any particular section. Nevertheless, there are a few general principles which it seems proper to discuss here.

On large farms, which are especially common in the West, there is much actual area lost by sheer wastefulness in cultivation. For instance, a wide strip is left for turning ground and then perhaps not utilized, and again the plow may be allowed to run quite a distance before it begins turning a furrow. If the amount of land thus thoughtlessly wasted could be calculated, the result would be surprising. Suppose a field of 200 acres produces 3,800 bushels of wheat, does this necessarily mean a yield of 19 bushels per acre? Is it not more likely to be 20 bushels per acre from an area of only 190 acres actually growing the crop? If the latter be true, there is a clear loss of 10 acres, or 200 bushels, which, at 40 cents per bushel, would pay more than half the bill for thrashing the entire crop, even at a rate of 4 cents per bushel for the work.

It is found, as a rule, that very early and deep plowing is best. This is especially true in arid regions, where conservation of moisture is a very important matter. In such districts subsoiling may be practiced also to advantage, according to the nature of the subsoil.[1]

For spring sowing plowing should generally be done in the fall, and for fall sowing plowing should be done soon after harvest. In spring-wheat districts summer fallowing is sometimes practiced. This gives a much-needed rest to the land during constant wheat cropping. Root or forage crops may, however, occasionally serve the same purpose, besides being a source of additional profit from the land.

After considerable experience and investigation, the writer has come to the conclusion that a roller should never be used on the Western plains, except in the case of late plowing, and even then it should be used only before drilling. This is owing to the fact that roughness of surface is valuable for holding moisture and checking the injurious action of dry winds. The seed bed should be made very fine and mellow before drilling, and wherever possible the drill rows should run east and west. Strict attention to such general principles as the foregoing will result in an increase in certain seasons of as much as 5 or 10 bushels per acre.

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[1]For an extended discussion of tillage for arid regions, see Prof. Milton Whitney's article in the Yearbook of the U. S. Department of Agriculture, 1894, p. 129, under "Conditions in soils of the arid regions."

TIME OF SEEDING.

The proper time for seeding varies, of course, with the latitude, while depending also occasionally on the locality and on the variety used. But whatever the conditions otherwise, it is a safe rule to sow at a period which is considered early in the locality where the sowing is done. Experiments conducted at several State experiment stations and in Canada show somewhat remarkable increases in yields, due to early seeding. In the case of four different seedings, made at intervals of one week, the average results for two to four years showed a difference in yield of from 10 to 26 bushels per acre between the earliest and the latest seedings, the difference being in favor of the former.

In apparent contradiction of the foregoing statements, it seems to be pretty well established, though as yet scarcely satisfactorily explained, that spring varieties when used for fall planting must be sown quite late. The seeming contradiction, however, is perhaps only apparent, for in regions where the character of the climate permits, an extremely late fall sowing, say as late as December, may as correctly be called a very early spring sowing. Indeed Turkey, Odessa, and allied varieties in ordinary seasons may be sown in western Kansas and Nebraska in any month of the winter with equal probabilities of success. In the Northwestern States especially only hardy winter varieties should be used for early fall sowing. Spring varieties will kill out in such localities, although abundantly able to make a good start when planted early in the spring. Varieties best adapted to winter seeding in the Northern States are perhaps yet to be found, and this brings us to a consideration of the selection of varieties.

SELECTION OF VARIETIES.

In considering this question perhaps one of the first things to bear in mind is the utter uselessness of giving any attention to announcements made by certain quack seed growers of new varieties that make such astonishing yields as 50 to 60 bushels per acre where the farmer's best average before had been only 25 bushels. The very fact of such a claim being made for a variety at once stamps it as a fraud. Besides the exaggerated claims made for the new variety, there is always an excessive charge of perhaps \$15 per bushel, which is generally a second evidence of fraud. It is a matter of regret that reliable seedsmen are occasionally compelled to compete with such men. Whatever may be in store for the future improvement of cereals (and the writer believes there is much), there is not at present a known variety in the world that will, of itself, without proper attention to rational methods of farming, give an excess yield over other varieties of as much as 25 bushels, or in fact of as much as even 10 bushels. Nor can any variety be so much better than others in this respect as to justify a price of \$15 per bushel—a price which many farmers have

paid. It is the recognized province of the experiment station in each State to determine what varieties are best adapted to particular localities in the State, and if they are not informed as to such matters others are not likely to be.

The judicious selection of varieties is a matter of much importance. There are, no doubt, certain scientific principles which, if better known, could be almost wholly and safely relied upon in choosing varieties for certain localities. Even with our present knowledge much may be gained in future by proper attention to such matters. Having given special study to this subject for a number of years, the writer feels justified in presenting the following conclusions with a fair degree of assurance:

(1) There are three great groups of wheats with which this country is particularly concerned: (*a*) The soft bread wheats, (*b*) the hard bread wheats, and (*c*) the durums, or macaroni wheats.

(2) Dividing the United States crosswise into three divisions of approximately equal width, the three wheat groups may, in a rough way, be assigned, according to their adaptability, to these three divisions as follows: (*a*) The hard wheats to the Northern States, (*b*) the soft wheats to the States in middle latitudes, and (*c*) the durums to the Southern States. In actual experience such distribution is, of course, not exactly attained, because the durums are but little grown in this country. When tried here, however, they do best in southern latitudes, as, for instance, in Texas, where they have been grown with success; and, moreover, the hard and soft bread wheats are grown interchangeably as to latitude. However, the general distribution of the three groups is about as above.

(3) The terms most commonly applied to the three groups are hard wheats, soft wheats, and durums. The last named are also hard wheats, but are very different in character from the first group. The soft wheats are called club, square head, white, etc.

(4) The hard wheats are, as a rule, hardy and especially drought-resistant. They resist the orange-leaf rust (*Uredo rubigo-vera*) quite well, are perfectly adapted to roller milling, and contain a large per cent of gluten, thus making the best bread.

(5) For the general market, therefore, special attention should be given to raising these hard wheats. No ordinary bread wheat does well in the extreme South, but there should be greater effort to push hard wheats into middle latitudes, such as in Kansas, Missouri, Ohio, southern Illinois, and Indiana. This has already been done to some extent and should be continued.

(6) In foreign markets Kansas hard winter wheat flour has already gained a reputation distinctively its own, and is classed by some as next to the best Hungarian grades in quality.

(7) The sooner millers make a more general use of hard wheats the better, for these are sure to be the varieties most in demand and those

which will grow most successfully in the greater portion of the wheat belt. It is little more than a decade since hard wheats were rarely seen in the region south of Iowa and Nebraska, but now they are the kinds generally grown in the States of the plains.

(8) Much of the work of adapting hard wheats to middle latitudes has been done by acclimatizing northern spring varieties, thereby gradually changing them to winter sorts, but it is a question whether it is not better to introduce hard winter varieties direct.

(9) As before stated, the finest class of bread wheats in the world is grown in southeast Russia. As this region is characterized by a deep, black earth ("Chernozem"), an arid climate, long and severe winters, and hot, dry summers—conditions very similar to those which prevail in our own wheat belt—these wheats should by all means be more extensively tested in the United States than they have been. The wheats in question are both winter and spring-sown varieties. The plants can be readily distinguished at some distance when grown with different varieties in small plats, as they are dark green; slender; with long, narrow leaves; small, narrow, compressed heads; small, very hard, red grains, and often (in spring varieties) have a velvety surface. The Turkey, Ames, various sorts called Odessa, Meekins, Mennonite, Krimsh, De Theisse, Girka, Budapest, etc., are examples of such varieties. The high-grade Chubut wheats of southern Argentina are also of much the same quality.

(10) The average per cent of dry gluten contained in ordinary bread wheats is about 10, but many of these hard Russian sorts contain over 14 per cent.

(11) Hard wheats do not usually give remarkable yields, but their average for a series of years will often exceed that of soft wheats, and they almost invariably weigh more per bushel.

VARIETIES FOR SPECIAL PURPOSES.

In wheat growing it is of importance to note that certain kinds of wheat are best adapted for certain uses. As already stated, the hard wheats, as a rule, make the best bread. The kind of flour demanded in foreign markets, however, depends much upon the locality to which it is exported. It is said, for example, that our northern wheat flour is not as desirable in Central American markets as that made farther south. At the Galveston elevators it is claimed that it does not keep so well in transit. The bulk of the hard wheats shipped to England is nearly always mixed with soft wheats before grinding.

The manufacture of macaroni has recently given promise of much success in this country. It is claimed, however, by some that the quality of the Italian product is unmistakably better than that of the home product, and that the preference given to the latter by many is due chiefly to the difference in price, the American brands usually selling at 2½ cents per package less than the Italian. It is doubtful if there

is much truth in this, but if so the difference in quality in favor of Italian brands is most likely due to the difference in varieties of wheat used in the manufacture. In Italy the durum wheats grown so generally in the warm regions near the Mediterranean Sea are used exclusively for this purpose. It will be seen, therefore, that the further encouragement of the macaroni industry in this country will possibly develop a considerable home market for durum wheats, which give promise of successful growth in the Southern States, especially Texas. Investigation will show that American macaroni is already finding its way into foreign markets.

In the manufacture of crackers the best quality of soft white wheat flour is required. The great bulk of the flour used for this purpose in English factories is imported by them from the St. Louis mills, which turn out soft wheat flour mainly.

CROSS BREEDING OF WHEAT.

This is a comparatively new feature in agricultural science, but its effectiveness in improving the wheat plant is nevertheless now well recognized by agriculturists generally. Some of the best-known varieties which were produced by cross breeding and are now firmly fixed are those of Pringle and Professor Blount in this country, and Carter Bros. in England. In more recent years R. & J. Garton, of England; Farrer, of New South Wales; Professor Saunders, of Canada; Prof. W. M. Hays, of Minnesota; A. N. Jones, of New York, and others, have produced in the same way a great number of new varieties, most of which, however, are not yet sufficiently well established to indicate what their value will be. Over one hundred of the varieties produced by Farrer have been tried by the writer in this country, but most of them have succumbed to the severe climate of our wheat region. As a rule, however, they show much more vigor than the ordinary varieties from that country, and some of them bid fair to establish themselves firmly in the United States as desirable varieties.

There is no doubt a vast field for improvement of cereals in this way, and it would be well for the experiment stations to give this subject more attention. Cross breeding adds so much vigor, and wheat is such a strictly self-fertilizing plant, that it would probably be of much value to at least occasionally practice cross pollination even between separate plants of the same variety, and thus obtain a fresh start, with renewed vigor, from the offspring of such crosses. But aside from the general effectiveness of cross breeding there are particular cases in which it is of very great value. For instance, if a hardy bearded variety which is well adapted to a certain locality and a good yielder is crossed with a bald variety of merit, the beards may be gotten rid of and the good qualities still retained; or varieties which are liable to rust, but are otherwise good may be made more rust resistant if crossed with a variety possessing this quality.

SELECTION OF SEED.

Many experiments made in recent years show the advantage of using large and vigorous seed in growing various field and garden crops, but it is only lately that attention is being given to the use of such seed in wheat growing. At present experiments are being made at several different places to test this point with reference to wheat, three grades of seed—small, medium, and large—being used. Too much attention can not be given to this subject. Many choice varieties have been developed by selecting from a field certain unusually good heads, planting the grains of these separately, and thereafter selecting the best each year. It has already been satisfactorily proved that the old idea that rust-shriveled grains give as good returns as large, healthy ones is erroneous. About the year 1876 a semihard, red variety, known as Grass wheat (probably an Odessa sort), became quite popular in northern Kansas, and was widely used for ten or twelve years thereafter. However, as the variety was adapted for either fall or spring sowing, and the spring-sown crop was always inferior to the fall-sown, the consequence was that two grades were produced from the one variety. As the fall-sown crop brought the better price, it became the practice to sell all the winter wheat and use the worst of the spring crop for fall seeding. It was claimed that this practice made no difference in the quality or quantity of the winter wheat, but about 1888 Grass wheat began losing favor among wheat growers, having lost much of its original good quality, and finally gave place to Turkey, Fultz, and other varieties. Now, there is no doubt that the deterioration of this variety was due, in great part at least, to the constant use of the very inferior shriveled spring grain for fall seeding. Many other instances of the so-called "running out" of varieties is probably due mostly to similar causes. However, even under the best treatment it is a pretty well-established fact that certain varieties, when introduced into new localities, will in time change quite materially in quality of grain. This is especially likely to be the case with hard northern sorts when transferred to warmer and moister southern latitudes. Probably the only remedy in such cases is to make an occasional fresh importation of seed.

The matter of seed selection is of such vital importance that probably nothing would be of more benefit to the wheat grower than the establishment of special small seed plats of, say, 1 to 5 acres, from which to select seed each year. The following plan is recommended: At harvest time cut from a good field a strip of the best portion, first eliminating all rye and other foreign heads and large weed seeds. After thrashing the wheat from this strip, grade it by means of a fanning mill with special sieves made for the purpose, so as to obtain only the largest and most vigorous grains. Use the best grade of wheat both for sowing the small plat and for the general crop the

next season. The next year use none of the field crop for seed, but after grading the wheat from the small plat, as before, use the very best of it for sowing the small plat and all the remainder for sowing the large field, and so on from year to year. In this way seed is never taken from the general crop, which can not be given the same care as the small plat, and there is a constant selection of seed, which is more and more rigid every year. Moreover, there is no extra labor involved, except the small amount required for grading the seed each year.

It is stated that systematic selection of seed wheat is already being practiced by a few Michigan wheat growers, but in just what way the writer can not state.[1]

DISEASES OF WHEAT.

SMUTS.

The subject of cereal smuts and their prevention has been brought to the notice of agriculturists so frequently that it will not be discussed in detail here. It is strange that a treatment so simple, cheap, and efficacious as that with hot water or potassium sulphide is practiced so little by farmers, especially in the Northern States, where bunted wheat is so common that millers complain of it constantly. All millers in Minnesota and the Dakotas should absolutely refuse to receive bunted wheat, or at least should severely dock the seller. In this country there is certainly no longer any reasonable excuse for the presence of bunt, or stinking smut, as bulletins describing in detail the treatment for smuts have been distributed over the entire country by the Department of Agriculture and the State experiment stations.

The loose smut of wheat has never yielded to these preventives in any satisfactory way. Of interest in this connection is the series of experiments conducted by Mr. F. L. Maddox, of Eastfield, Tasmania, the result of which may throw much light on the life history of loose smut and probably show why the same preventives have failed to be as effective, if effective at all, against this smut as against bunt.

The results derived from the experiment were, briefly, as follows: (1) Artificial inoculations of the wheat head with loose smut while flowering produced no smut in the head that season, but the grains when planted produced smutted heads the following season; (2) treatment of the grains of the inoculated heads with hot water and potassium sulphide treatment has no effect in preventing smut the following year, though the same treatment was quite effective with the bunted wheat. The natural inference is that in case of the grains from heads artificially inoculated with loose smut the fungus, having already infected the seed, can not be killed without injuring the grain. These

[1] For a further discussion of this topic, see Bolley on "Rational selection of wheat for seed," Bulletin No. 15, North Dakota Agricultural Experiment Station, April, 1894.

experiments, apparently carefully performed and accompanied as usual with sufficient checks, seem not to have been noticed in this country.

RUSTS.

It must be admitted that as yet there is no preventive or remedy for wheat rust, at least as far as combating the rust directly is concerned. For some time strong efforts have been made in several different countries (including the field experiments by this Deparment for two years) to discover and establish rust-resistant varieties, but so far only partially successful and rather conflicting results have been obtained. It has been found that certain varieties are highly resistant to the orange-leaf rust, and that some of these varieties are fortunately the best bread wheats, being hardy and having hard grains with good milling qualities. They are, however, not generally good yielders. Even among the varieties of the bread-wheat group a few are found to be somewhat rust resistant, but otherwise do not possess good qualities, and again quite a number are hardy and productive, but are not rust resistant. Varieties that are quite rust resistant in Australia sometimes become badly rusted here, and this is true even to a greater extent of American sorts in Australia. There are differences in resistance of the same variety in different localities in the same country. Such variation is most likely due to changes in the constitution of the plant caused by changes of climate. Our hard American-grown Fifes are known to become much softer when grown in Australia.

On account of the great variation and consequent uncertainty in the rust resistance of varieties, it seems that the production of early varieties, that will ripen soon enough to escape the rust, is nearly, if not quite, the most important feature in sowing wheat. Our Early May (though a rather soft sort), the Roseworthy and Allora Spring of Australia, and a few Japanese sorts are worthy of notice in this respect. In the States of the plains the early varieties have the additional advantage of being more likely to escape shriveling of the grain by drought. Besides this, even the most rust-resistant varieties are occasionally much injured during the seasons when the rust is unusually bad or the wheat unusually late in ripening.

The writer is confident, however, that after all, the orange-leaf rust does very little, if any, damage to the grain in this country, although perhaps it injures the straw considerably; and that all experiments, including the writer's, heretofore made by botanists in this country with a view to prevention or remedies, have been entirely with the wrong species of rust. From personal observation and inquiries extending over four years, the writer believes the inevitable conclusion is that in all cases of really serious damage to the grain by rust the black-stem rust (*Puccinia graminis*) is the real cause,

although the other species may also be present in abundance. In such cases the extreme degree of injury is seldom, if ever, realized by those who are not financially concerned. The grain becomes shriveled up to almost nothing in from one to three days, and the straw at harvest time is almost rotten and is easily rubbed into small bits. The accompanying illustration (fig. 139) of healthy and shriveled grains of Jones Winter Fife wheat, from two distinct localities in Kentucky, harvested in 1894, shows the disastrous effects of this black-stem rust. Such blasting effects, however, occur, as a rule, only in southern latitudes, but are occasionally seen in Ohio, Michigan, Indiana, and southern Illinois. In the South the destruction is quite often complete, and in such cases the fields are pastured instead of harvested in order to get as much good from them as possible. In Texas vast districts of some of the

FIG. 139.—Healthy and shriveled grains of Jones Winter Fife wheat.

best wheat lands of the plains have been abandoned by wheat growers, solely on account of the destructive effects of this parasite. So far as known, there is no resistance against this rust by any variety. The very hard durums, which are practically proof against orange-leaf rust, yield readily to the black-stem rust. As yet the life history of the rust in this country is not wholly understood, and until it is there can be but little hope for the wheat industry in the South.

On the whole, then, the outlook for wheat culture in this country is good, provided proper attention be given to the many possible improvements such as herein suggested. Wheat is just like any other product, in that prices are badly affected by an oversupply of a poor article. A moderate production of a good article, brought about by a diversified and scientific system of farming, with a proper outlet for the product, is sure to develop and maintain a profitable industry.

PRUNING AND TRAINING OF GRAPES.

By E. G. Lodeman,

Late Assistant Horticulturist, Cornell (N. Y.) Experiment Station.

INTRODUCTION.

To most people the art of the vineyardist is a mystery; in fact, the vineyardist himself is very frequently puzzled unless he has studied the various modifying circumstances and conditions which exert an influence upon his vines; and yet, when the entire subject of grape culture is considered with regard to its underlying and fundamental features, the mass of minute details lose their apparent importance and a few essential facts stand out clearly, forming a framework upon which the living and variable methods may be arranged with due respect to their relative importance. The haze which has hung over what should be the simple operations of pruning and training the grape has discouraged many from examining into the comparatively easy problem of determining the most simple and economical line of treatment to be followed.

As the grapevine is seen growing in wild nature it is found to be a vigorous, self-asserting plant, steadily overcoming one obstacle after another and frequently climbing to great heights by means of its long, slender branches, which are provided with tendrils that enable it to retain possession of its ever-widening domain. When such an energetic and successful plant is compared with its dwarfed and geometrical neighbor of the vineyard, there is abundant reason for wonder as to how the wild and rampant child of the woods could be so radically transformed into a small, compact growth, which evidently feels its commercial importance and quietly settles down to steady work. Yet, the change can be made with comparative ease, and the various steps of the operation are at present illustrated in the numerous commercial vineyards of the world.

The vines of many Italian vineyards have for centuries been trained over trees in imitation of the trellis furnished the vines by nature. Fig. 140 shows this primitive method of grape training. Five or six vines are planted about each tree, and by means of stakes and strings or wire the shoots are carried to the branches. Here they are very commonly allowed to roam at will, the only pruning that is done being to cut back more or less of the shoots produced each year. The trees are planted so close together that the vines often extend from one tree to the next, thus forming a continuous tangle of grapevines and

trees. Although this method can scarcely be termed pruning, still it is an advance; and the fruit borne is also to a limited extent benefited by such thinning. Where grapevines are allowed to run over arbors, they generally receive similar treatment, but in such cases dense foliage is sought more than fine fruit. Such practices are, as a rule, wholly unsystematic, and therefore can not be discussed in connection with our best methods.

FIG. 140.—An Italian method of grape training.

A few terms must be clearly understood before any of the details of grape training can be satisfactorily considered. The following definitions explain many terms used in this article:

A shoot (fig. 141, *s*) is a green or immature growth less than one year old.

A cane (fig. 141, *d*) is a matured shoot, as found at the end of one year's growth.

An arm (fig. 141, *g*) is a matured cane, two or more years of age; its length and form are not changed from year to year, its office being to produce canes or branches. An arm is also frequently called a "cordon," especially by Europeans; the cordon is spoken of as horizontal, vertical, or oblique, depending upon the direction in which it lies on the trellis.

A branch (fig. 141, *h*) is an arm which varies in form and length from year to year, being modified by the addition of spurs, or by the cutting away of older portions of its body.[1] It is commonly composed of spurs more than one year old.

A spur (fig. 141, *b*) is a shortened or pruned cane, generally bearing only from one to four buds; if cut longer, such a portion is commonly spoken of as a cane and not as a spur.

Spurring refers to the operation of cutting back a cane to the length of a spur.

FIG. 141.—Ideal vine, showing different methods of cane renewal.

Stem, or trunk (fig. 141, *i*), refers to that portion of the vine found below the origin of the lowest arms or branch; it extends to the ground. In the Kniffin system, the stem proper generally extends to the top wire of the trellis.

The operation of pruning the vine is performed for the sole purpose of removing such wood as will not bear, or such as is supposed to interfere with the production of the finest crop of fruit that the plant

[1]A branch as here defined is equivalent to the term "spur" as used by some authors. The majority of writers, however, consider a spur as being a cane cut back to a small number of buds, as defined in the text. It seems desirable to distinguish these two parts of the vine. The Germans designate the enlargements which result from such repeated cutting back, or "spurring," as "stammknoten" (stem knots); this is practically equivalent to a "branch" as above considered, although in America the enlargements are not commonly seen.

is able to mature. Its primary object, therefore, is to reduce the amount of bearing wood and thereby thin the fruit so that the roots of the vines are not taxed beyond their capacity.

Fig. 142 represents a vine which has been systematically cut back every year, and which is once more ready for its annual pruning. The various portions are lettered, *i* being the stem; *g*, the arms; *b*, spurs; *d*, the canes of last year; *s*, the matured shoots of the last growing season. Not entering here upon the subject of renewal, which is treated in detail elsewhere, we will assume that the pruning is to be done only for the purpose of removing superfluous branches. All the fruit is of course borne upon the shoots which grow from the buds now found upon the canes; the canes, therefore, must be removed and not the older wood, for the latter serves as the framework upon which the canes are maintained.

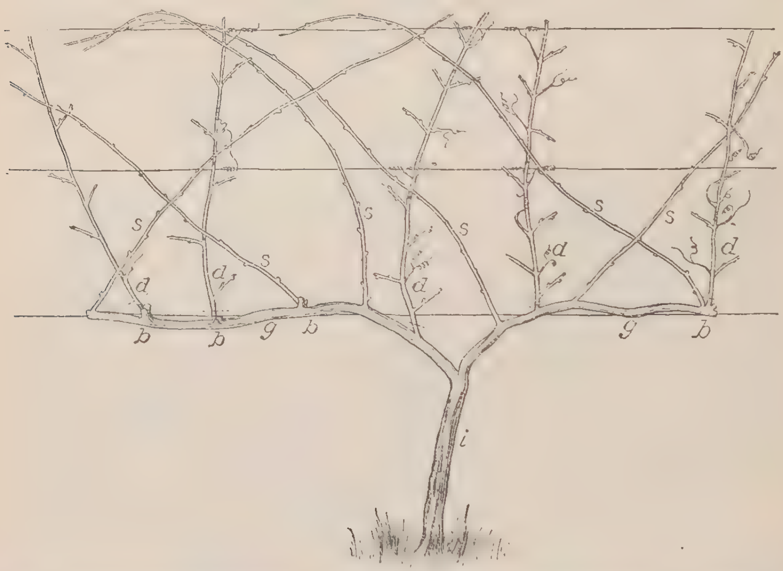


FIG. 142.—Vine trained on the Brocton high renewal system, ready for pruning, as shown by the cross lines at the bases of the old canes.

In cutting away the canes, all wood which has not properly matured should be removed,[1] and those shoots which have made an excessive growth, forming "bull canes," are also undesirable. The medium-sized, short-jointed, and well-matured wood is to be preferred, and such wood only. Yet, some of this well-developed wood must also

[1] The best instrument to use in grape pruning is a pair of stout, sharp pruning shears; a heavy knife will answer the same purpose, but it is not so easily handled. A saw is of no use, except for taking out old arms or stems. Summer pruning is performed with the aid of a light instrument which readily cuts green tissues; common shears are often used, as well as long thin-bladed knives, sickles, etc. A ragged cut should always be avoided.

be sacrificed, until the amount allowed to remain upon the plant is reduced to the proper proportion. Assuming that the plant can mature the fruit produced by twenty-four buds (the number of buds left may vary from two to fifty or more), about thirty buds could be allowed to develop. These should be uniformly distributed according to the system of training employed; they may be left upon five canes, each cane having six buds, as shown in the illustration, or the distribution may be varied according to circumstances. But such is in general the method adopted in the vineyard for estimating the proper amount of bearing wood to leave upon each vine. As a result of such systematic pruning, the fruit upon the vine is larger and more fair; it is also produced more regularly, since the maturing of too heavy a crop weakens the vine so that it is unable to mature even an average amount of fruit the following year. A vine properly pruned and fertilized should bear about the same amount of fruit each year from the time it comes into full bearing. A secondary benefit derived from pruning is the reduced stature of the plant. This allows more vines to be set upon a given piece of land, and it enables the work of cultivating, spraying, and harvesting to be performed much more easily and profitably.

Training, on the other hand, is almost wholly a matter of convenience. It does not affect the strength of the vine or the value of the crop in any essential particular. The training of a vine refers to the disposal or arrangement of the various parts of the vine after pruning has taken place. The method of training adopted determines the operator to leave certain growths in certain positions, not because more or better fruit is expected, but for the reason, perhaps, that the fruit may be harvested with greater ease, that a laborious operation may be wholly dispensed with, or that there may be less danger to the maturing crop from winds or other natural agencies. The method of training adopted by a vineyardist is largely the result of personal preference, or of education, although soil and variety are important factors in the selection of a system. The health and vigor of the vine are rarely affected by the method in which it is trained, and although some system of training must be adopted in every vineyard, still altogether too much weight has been laid by most horticultural writers upon the peculiar merits of the various systems, while the actually ruinous effects of bad pruning have not always been sufficiently emphasized. A vine properly trained is desirable, but a properly pruned vine is essential to the highest success.

The importance of this subject necessitates a somewhat detailed statement of the principles which are vitally connected with the proper pruning of the vine. These principles serve also as the foundation for all systems of training, and they can not be ignored without more or less injury to the plants.

(1) The amount of fruit which a vine can bear and mature in

highest perfection is limited; when this limit is exceeded the fruit deteriorates.

(2) Upon the fruit the effect of overproduction is to reduce the size of the berries and of the clusters, and probably also to impair the quality; the vine makes a poor growth, the foliage is small, and the vigor of the plant is generally reduced. When a vine has been allowed to overbear, especially when it is young, years may sometimes be required before the vine returns to its normal condition.

(3) A plant which is carrying less fruit than it is capable of maturing generally produces a very heavy foliage and an excess of wood. This may probably be explained by the supposition that the energies of the plant are directed almost entirely to vegetative activity.

(4) The most difficult and important feature of grape pruning is to be able to judge of the kind and amount of wood which should be allowed to remain upon the plant. This amount is dependent upon soil, variety, climate, character of the season, and to a limited extent upon the method of training. The paramount importance of having a properly balanced top and root system is most fully realized by American vineyardists of long experience. Years of study, especially the study of the variety of grape and of the soil upon which it is growing, are brought to bear upon each individual vine when it is pruned, and in no direction can the skill of the vineyardist be more clearly demonstrated than in questions regarding the amount and kind of bearing wood that is allowed to remain. No rule-of-thumb will cover a living and sensitive organism like the grapevine; in pruning, judgment must be exercised at almost every step. But it is fortunate that considerable variation may be allowed without serious consequences, or the profitable culture of the grape would indeed be a hopeless task. Yet, the less the reliance placed upon this allowed variation the better will be the vine.

(5) All the fruit of the vine in any one year is borne upon the shoots of that year, which grow from the canes produced the preceding year; and since the number of clusters borne upon a single shoot is fairly constant (varying generally from one to three), the number of buds left upon a vine when it is pruned determines with considerable accuracy the number of clusters which the vine will possess. These facts serve as the chief guides to the operator in the vineyards when estimating the probable capacity of a vine during the next season of bearing. Usually more buds are allowed to remain than would be safe if each one were sure to be perfect; an excess of 10 to 20 per cent is generally left in New York vineyards to take the places of such buds as are imperfect, or of those which become injured.

(6) The position of the bearing wood upon a vine is of secondary importance as regards the effect upon the quantity and quality of the fruit; but as a frequent change or renewal of the entire top of the vine appears to be desirable, the young bearing wood should be as near

the root of the plant as circumstances will allow. When the important relation of these essential points to successful grape growing is thoroughly considered, the secondary character of the training of the vine becomes apparent. A system of training may become popular in a locality simply as the effect of some trifling cause, and not as a result of extended comparisons or experience; it is well understood and therefore used. Yet, there is scarcely a system which is not more or less modified by the individual grower—so much so that often many variations of some well-known method will be found in the same locality. Each vineyardist is a stanch supporter of his own method, and the conclusion which one must necessarily reach is that the grower is the main factor, the system being merely a convenience capable of much variation. Yet, every important grape-growing district has one or more characteristic methods of training its grapevines. This plainly shows that such methods are well suited to the locality and to the varieties of grapes grown there. For this reason they deserve study, as well as comparison with other methods in successful use. When the advantages and disadvantages of the various typical systems are once well understood, it is a comparatively easy matter to select one which will prove successful even under peculiar circumstances. In case of necessity an entirely new method may be adopted to suit the requirements of a certain locality; all that is essential is to adapt the system to the principles stated above and to limit all modifications in accordance with them.

METHODS OF TRAINING.

The systems at present in use for training the grape are many, but fortunately they may be reduced to a much smaller number of type forms. These types, for convenience, may again be separated into three general groups; although this subdivision is not as logical as might be desired, on account of several intermediate forms, it still assists admirably in showing the relationships of the various forms, and it will serve as the basis for the discussion following.

The groups are primarily separated from each other by a single character, viz, the position of the fruiting portion of the bearing shoots. This portion may be trained in three directions: (*a*) Upward, forming the upright systems; (*b*) horizontally, forming the horizontal systems; (*c*) downward, forming the pendent, or drooping, systems.[1]

(*a*) The Upright Systems.

The class comprising the upright systems of grape training includes a larger number and a greater variety of methods than either of the other groups. The forms vary also in complexity to such an extent

[1] This classification was first made in Bailey's American Grape Training, 1893.

that the simplest as well as the most complicated systems may here be found. A thorough understanding of the latter may be much more easily obtained if the simpler forms are first considered. Summer pruning is not practiced in any of the American systems of this group in common use.

THE STAKE, OR POST, SYSTEMS.

These systems belong almost entirely to the upright group, there being but one or two forms which should be elsewhere classed. The stake systems are particularly popular in Europe and in California, the European grape, in outdoor culture, being very commonly trained in this manner.

The influence of the soil upon the vigor of plants of the same variety of grape can scarcely be overestimated. Upon rich soils a rampant growth is produced, while on poorer land the plants become more or less dwarfed. This variation in the size of the plants causes the systems of training the same variety of grape to vary in different localities. It is upon the less fertile land or with weak-growing varieties that the stakes are principally employed. The vines growing in the high altitudes of the Alps are often exceedingly dwarfed, so much so that the number of buds upon a plant is frequently reduced to only two or three. The annual growth is also trifling, not aggregating more than 3 or 4 feet during a season. In such cases the vines have but one stem and no arms; the canes are regularly cut back to one or two buds, and the shoots produced by these are tied to stakes driven into the ground. The growth is therefore practically all upward, and the fruit hangs near the surface of the soil.

Upon richer land the shape of the plant is modified considerably, but the same principles are applied in training. Instead of having a simple stem, from the top of which one or more shoots are allowed to grow, the stem at its summit divides into a varying number of branches. Fig. 143 shows a vine grown in this manner. The shoots are trained in different ways in different localities. They may be merely tied together, as shown in the illustration, or the shoots of one plant may be fastened in the same manner to shoots from other plants, as is done in the Miramont system. Stakes are most frequently driven into the soil, and these serve as supports to the upright growing shoots.

The length of the stem also varies considerably in different localities. In the vineyards about Provence, France, the branching is produced almost at the surface of the ground, and when the vine is pruned the parts above ground show irregular somewhat star-shaped masses of wood; the stubs of the shortened canes extend upward from these short, sprawling branches. In Beaujolais the branching takes place several inches above the surface of the ground; and in Languedoc the stem is still longer, as shown in fig. 143. These

systems are sometimes referred to as the "goblet" systems, since when the shoots are tied together the plant bears a certain resemblance to such a glass. As a rule, these vines make comparatively little growth, and the canes are severely cut back each year.

The more vigorous American vineyards can not be trained satisfactorily in this manner; even when some of the weaker sorts are to be grown upon stakes heavier and longer pieces are necessary. These posts may be set at intervals of 6 or 8 feet each way and firmly placed in the ground. Since the canes are left fairly long in this country, they are frequently placed spirally about the post and then tied. In California, where the post systems are almost exclusively adopted, the head of the vine is only a short distance from the ground. When the vines are pruned, three or four canes are left to each plant, and these canes are not cut much shorter than 5 feet; they are then tied to the post.

FIG. 143.—An upright system of grape training commonly seen in European vineyards.

The shoots which are formed may also be tied upright to the posts until they extend over the top; they are then allowed to droop at will. But if this tying is neglected, as is frequently the case, the majority of the shoots will gradually bend over on account of the weight of the fruit, and eventually hang as in the pendent systems. The number of pendent canes will vary with different varieties; nearly all the shoots of the Delaware grape grow downward under such circumstances, while the Catawba possesses a much more upright tendency. The Delaware grape and other moderate growers are more successfully trained in this manner, but the vigorous sorts of the Concord type do not readily allow themselves to be confined in such close quarters.

Another system of post training differs radically from the above.

Instead of being spurred or branched near the surface of the soil, the stem is carried upward in a spiral to the top of the post, and the short arms, of which there are generally two or more, are formed at the summit. The canes are cut back to the desired number of buds, and the shoots grow freely downward. This system, which is followed in some parts of western Michigan, really should be included in the third class, but as it is commonly known as a variety of the post system it is here considered with the others.

Leaving these simple systems, in which the method of training presents no complicated features, a much more complex group will be considered. The shoots are still trained upward, but their position is, theoretically, determined with almost mathematical precision.

THE HORIZONTAL ARM SPUR, OR FULLER, SYSTEM.

This system presents the above features in a particularly formal manner, and when the details of this method are fully mastered the other systems present no special difficulties. It is not so fully discussed on account of its wide use (for, as a matter of fact, the horizontal arm spur system is little in favor among vineyardists), but rather because it offers an opportunity to show in an almost ideal manner most of the points which arise in connection with nearly all the other systems in this as well as in the other two groups. Its principal merit therefore lies in its value for illustrative purposes.

When a grapevine is first set in a vineyard, it closely resembles the plant shown in fig. 144. Such a rooted cutting may be one or two years old, the former being preferable in the majority of cases. The cane is cut back to two buds, and during the first season its shoots are allowed to lie prone upon the surface of the soil.

Assuming that all the pruning is done a short time before the arrival of the growing season, at the beginning of the second year the newly set vine will have a well-established root system and two canes of varying length. The weaker of these canes should now be removed entirely and the other should be cut back so that it remains about 18 inches in length. If cut in this manner, the cane is sufficiently long to reach to the lowest wire when the trellis is made. By some, however, the cane is again cut back to two buds, as in the preceding year. This causes the stem to branch near the surface of the ground, instead of at the lowest wire. Either method may be followed to advantage, although single stems render cultivation more easy. This cane, whatever its length, is to form the stem of the vine, and as there are to be two arms, as shown in fig. 142, *g*, only two of the strongest shoots need be retained after the growths are sufficiently advanced for their comparative vigor to be seen. It is better that all the other shoots be then removed, so that the two which are to remain may become the stronger. But if the unnecessary growths are not removed until the following spring no material injury will be done to the vine.

At the beginning of the third season the vine consists of a root system three years old, of a stem mostly two years old, and of two canes growing from the upper portion of the stem each one year old. These canes should be cut back so that they will not extend farther than one-half the distance to the next plants in the same row; weak-growing varieties should be cut back still more, the important point to observe being that the amount of wood shall be reduced to such an extent that the vine will not overbear. In case the canes destined to form the arms are cut so short that they do not extend to the canes of the adjoining plant, the shoot springing from the last bud should, the fourth season, be cut long enough to fill its share of the vacant space between the vines.

The trellis should be put in the vineyard during the second season, although it need not be finished. The use of the lower wire, which should be from 20 to 24 inches from the ground, is desirable, as it allows the shoots which are to form the permanent arms to grow in the position they are to retain, and the pruning can also be more easily done. Two other wires should be added some time before the beginning of the next, or third, growing season. The second wire on the trellis should be about 20 inches above the first, and the third an equal distance above the second. These distances may require some change with varieties which are exceptionally weak or strong growers. Either No. 10 or No. 12 ungalvanized iron wire will answer; the former is of especial value when the posts are set far apart and in positions where an extra strain is put upon the trellis. All the wires should be firmly stapled to the windward side of the posts, yet the wire should be allowed to slip in the staples.

FIG. 144.—One-year-old rooted grape cutting.

The posts should be of some durable wood, as cedar, locust, white oak, etc. They should be long enough to allow them to be set firmly in the ground, and then to stand about 5 feet in height. The distance between the posts varies in different vineyards. The vines are set at distances varying from 8 by 8 to 10 by 10 feet, and the posts are so set that from two to four vines stand between two posts; upon light soils the longer interval is none too great, for in such cases the vines may be set more closely.

The end posts of each row must be firmly braced, so that they may remain upright when the strain upon the wire becomes severe. Many methods of bracing are in use. One of the most common is to drive a broad stake firmly in the ground from 8 to 12 feet from the end post, placing it between this post and the next one in the same row. A long brace is now made to fit snugly between this stake and a shallow notch which may be cut about halfway up the post. (See fig. 157.) If the brace is placed nearer the top of the post, the latter is apt to be pulled slowly out of the ground if a heavy strain is put upon the top wire. Another common method is to brace the second post in each row by running a strong wire from its tip to the base of the end post. This forms a very neat and effective anchor. A third method is to run the wire from the top of the end post to a stake driven in the ground from 8 to 10 feet beyond the trellis and in line with it. Such stakes should, of course, be driven in a sloping direction, so that they may more easily resist strain.

The wire is not fastened to the end posts by staples, as is done in the rest of the vineyard, for it varies considerably in length after having been fastened to the posts. The cold of winter shortens it considerably, and several devices have been invented to avoid the strain caused by this shrinkage. The weight of the vines also causes the wires to stretch more or less, and some practical method of tightening them is probably of greater importance than loosening them for the winter. Some simple form of reel, or a pin which may be turned when desired, will answer the purpose well. Many homemade devices of this nature are now in use, as well as some which are patented. They permit the trellis to be kept trim and taut at little expense. A very simple and practical way is to use a clamp, pulley, and rope for tightening the wire, and then to wind the slack about the post two or three times. The end of the wire is finally brought around and wound a few times about the stretched portion. This method is in common use.

Although these directions refer particularly to making a trellis for vines trained upon the horizontal arm spur system, they still apply in many respects to other forms of the upright systems. Whatever may be the method of training a vine, in building a trellis it must be remembered that the fruit is borne near the base of the shoots (fig. 141), generally within a space of about 18 inches from their point of origin. Consequently, it is at this point that ample support should be given. In the horizontal arm spur system the bulk of the fruit is of necessity borne between the two lower wires, and these bear a large portion of its weight. The burden is at first only partially shared by the third wire, but as the shoots are generally allowed to grow without check they soon cover the trellis, and the total weight of the vine is very evenly distributed.

Let us now return to the pruned vine at the beginning of its third

season's growth. The two canes which are to form the arms have been properly shortened and tied to the lowest wire by means of some soft, strong cord; willow shoots are often used. The buds (fig. 141, *k*) upon the canes are soon pushed into rapid growth, and the shoots (*s*) are at first heavy and easily broken by winds. This is a critical period in a vineyard, for the loss of the shoots means the loss of the fruit for that season. As soon, therefore, as the growths are long enough to reach the second wire they are tied to it, and the crop is thus brought into comparative safety. It may be necessary to go through the vineyard two or three times in order to secure all the shoots, but unless the work is thoroughly done the losses may be very great. The material used in this "summer tying," as the work is commonly called, may consist of any soft substance which is not too strong or too durable; grass, straw, bast fiber, raphia, and similar materials are frequently employed. They serve to hold the shoots in place, yet when the vines are pruned they do not interfere seriously with the removal of the severed canes from the trellis.

After the shoots have been tied to the second wire, they are generally allowed to take care of themselves. Most of them reach the third wire, and from this they may droop over even to the ground, or they may start to follow any of the three wires. Summer pruning is rarely practiced.

The heaviest annual pruning of the vine is done during the months of the year when the plants are dormant. In some European gardens the work is practically done twice. The first pruning takes place in the fall, after the foliage has dropped; this work is done by an expert and the canes are cut to the proper number of buds. But instead of cutting within a quarter or half inch from the terminal bud left upon each cane, the length of the wood projecting beyond these terminal buds may be 2 or 3 inches. Then the following spring cheap labor is employed to remove the long stubs left the preceding autumn, and the pruning is complete.

In America, the vines are most commonly pruned in early spring, before the first heavy flow of sap. In certain sections, as in western New York, not very much thought is given as to whether the vines will "bleed" or not. This indifference is frequently carried so far that the bulk of the pruning is done when the flow of sap is the heaviest, and the treated vines lose such enormous quantities of sap that they appear as if dripping from a heavy shower. No ill effects appear to have resulted from such practices, and the bleeding has had but little influence in determining the season of pruning. A vineyardist, however, will be on the safe side in pruning his vines before they will bleed.

Pruning a vineyard, as practiced in the East, may be divided into two distinct processes, "blocking" and "stripping." Blocking consists of pruning a vine as nearly as possible without the removal of

any of the brush. It requires long experience to do the work rapidly and well. The pruner estimates the probable capacity of the vine, compares the values of the canes which may serve as bearing wood the next season, removes those which are least desirable, and shortens to their proper length those which are to remain.

Stripping, as its name suggests, consists in forcibly tearing off the trellis the severed parts of the vines. These are thrown between the rows, to be removed either by wagon or by dragging through the vineyard a pole, 18 to 25 feet in length, by means of a chain attached to it at a point about 6 feet from one end. By this latter contrivance nearly every cane is caught up.

Although these two terms apply more particularly to the methods commonly practiced in Eastern vineyards, they also stand for similar processes where a vineyard trained upon the horizontal arm system is under treatment. But with this system the blocking of the vines is a comparatively easy matter. Assuming that the vines thus far considered in detail have passed their third season of growth and are in readiness for their next pruning, the work is done as follows: The canes which have been matured from the buds upon the arms of the vine must be spurred back to about two buds each (fig. 141, *b*). This doubles the number of buds upon the plant as compared with the preceding year, and consequently doubles the yield for the fourth year. In case the arms from adjoining plants do not extend to each other, the cane formed from the last bud upon the arms must be bent down to the lower wire and tied so as to extend the arm to the desired length. The framework of the vine is then complete, and after stripping, the vineyard is ready for its growth of the fourth season.

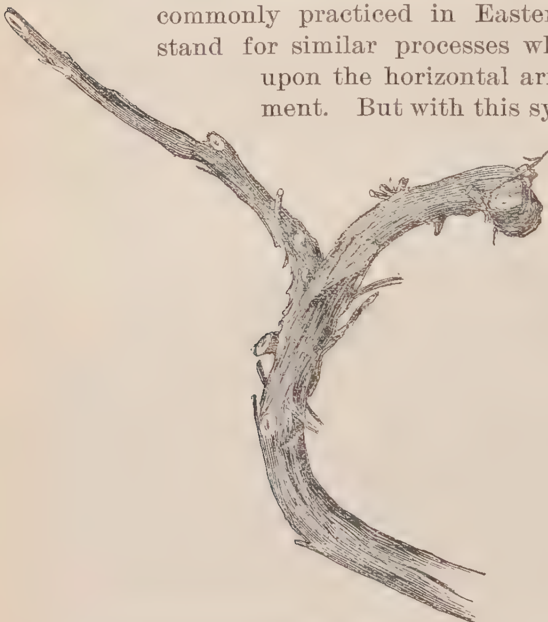


FIG. 145.—Annually lengthening branch.

The pruning for the fifth season is practically the same as for the fourth. There are, however, two canes to be shortened where last year there was but one. The buds may be reduced to the same number as before by cutting one cane away entirely and reducing the other to two buds, or the number may be increased by leaving both canes. In this way the number of buds may be controlled at will.

After the capacity of the vineyard has been determined, the pruning becomes a less difficult operation. The canes are each year cut back to the same number of buds, as already described. But the continually lengthening branches (fig. 141, *h*) soon become unsightly, and they must be renewed by young shoots from their bases. Fig. 145 shows a branch three years of age. Occasionally the branches are allowed to become much longer and much more irregular. On this account the system has not become very popular, although, theoretically, it is one of the best.

THE HIGH RENEWAL SYSTEM.

This system is very similar to the preceding; it is in fact a modification, which allows the general plan of the horizontal arm system to be used successfully in large vineyards, and it is almost the only one in use in the many vineyards of the lake region of central New York. The essential improvement in this system consists in the use of canes

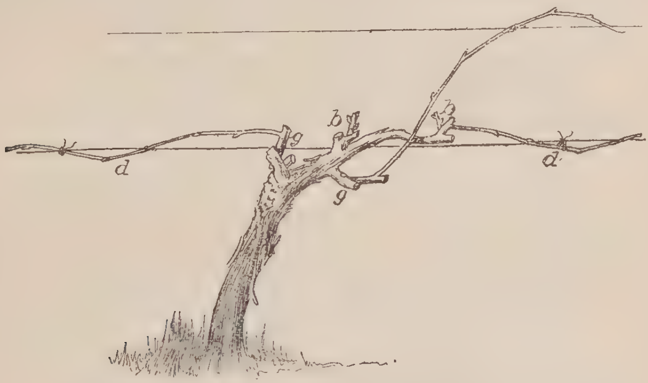


FIG. 146.—Pruned vine trained on high renewal system.

in place of the permanent arms above described. Fig. 146 represents a bearing vine trained in this manner, and at first sight it will be seen to possess many features of the horizontal arm spur system. But closer examination shows that the permanent arm (*g*), if it may be so called (it is frequently a spur), is extremely short, while horizontally placed canes (*d*) extend nearly halfway to the next plant. From these canes the bearing shoots are trained upward, as in the horizontal arm system; the shoots are tied to the upper wires in a similar manner. Vines trained according to the two systems are frequently almost identical in general appearance.

But the horizontal cane of the high renewal system must each year be replaced or renewed by another, and special provision must be made that such a cane may always be present when it is wanted. These canes are commonly produced from the very short arms (fig. 146, *g*) or from spurs *b*, which are left at the top of the stem of the

vine. The number of these spurs may vary from one to four, depending upon the richness of the soil and the vigor of the variety. As a rule, the weaker-growing sorts, or vines upon fairly light land, are most successfully trained according to this system, and the number of spurs left each year need not exceed two. Usually no trouble will be experienced in securing two canes from each of these spurs, but one cane from each spur, when cut to the proper length, will bear a sufficient number of buds for the capacity of the vine. The other canes may be spurred. Upon stronger soils, where more spurs are used, the number of canes is increased to three, four, or more. In such cases two canes may be tied horizontally to the lower wire, one on each side of the plant; two others are similarly fastened to the next wire above, although they are occasionally tied to the lower wire with the first pair. They are always placed in a horizontal position.

The stem of the vine may consist of one part, or it may be branched. Ordinarily it does not branch until near the lower wire, and then it divides into a varying number of arms and branches; these with their spurs form what is known as the "head" of the vine. The head varies exceedingly in form, but it always consists of the shortened arms, branches, and spurs, which bear the canes to be laid down upon the wire for fruiting purposes. A very desirable head is one which branches just below the lower wire and has each of the two arms supplied with two or more branches with spurs. The vine shown in fig. 116 answers most of these requirements, and is a fair representative of the system.

The trellis used for vines trained on the high renewal system is practically the same as that described for the horizontal arm spur system. It frequently occurs that vigorous varieties are grown upon strong land, and, as much wood is produced, the trellis should be so modified that it will support the heavy weight of fruit and foliage. In such cases a No. 10 wire will be none too heavy, and four wires will also prove superior to three. The fourth wire should be placed about 18 inches above the third. Longer posts must also be used.

Summer tying should begin when the shoots reach the wire above them. From two to four tyings will be necessary to put the vines in the best shape, and although the last number is rarely given, in luxuriant vineyards the advantages derived will repay the extra cost. By distributing the tops as evenly as possible over the trellis, air and sunlight are more freely admitted and the cost of picking is reduced. The pruning of the vine is also made easier, and the grower should take a greater pride in his vines when he sees them firmly and systematically attached to their supports.

THE BROCTON, OR CHAUTAUQUA, SYSTEM.

This system is the almost exclusive method of training grapes in the Chautauqua grape district. Strictly speaking, this method does

not belong to the group having the shoots trained upward; for in the Brocton system the shoots may be in a position which would place the system in any of the three groups which have been founded upon the direction in which the bearing portion of the shoot is placed. Yet, it is placed in the first group on account of the close relation which exists between these methods and the high renewal and horizontal arm spur systems.

The conditions which have given rise to the Brocton system are somewhat peculiar, and the methods indicate special adaptation to local requirements. Brocton is the center of the grape-growing industry of Chautauqua County, N. Y., and the land surrounding the village is notably fertile. The Concord grape makes a wonderful growth upon certain soils of the locality, and the most common way of checking the excessive vigor of the plant is to leave a great number of buds on the vines when pruning. It is no unusual sight to see a pruned vine with fifty or sixty buds upon the canes, and in some rare cases even a greater number may be left. If this number of buds were to be left upon vines trained according to any of the preceding systems, it would be found somewhat inconvenient to place all the wood in satisfactory positions. The Brocton system tends to avoid this difficulty, and it is therefore one of the best systems to adopt for vigorous varieties growing upon strong soils.

The distinguishing feature of the Brocton system is the position of the canes. These are upright, but the lower portion may extend horizontally along a wire, to remove the upright part farther from the center of the plant. These upright canes usually extend to the top wire of the trellis, and they vary in number from two or four to eight or ten, generally one-half of the canes being on each side of the plant. Each cane has from five to ten buds upon it, so that the total number per plant can be very easily ascertained, and a large or small amount of wood be left upon the trellis as desired.

Having thus outlined the general plan of the Brocton system, there still remain to be distinguished two types or varieties which differ from each other considerably. As a matter of convenience, they will be given separate names, although they still retain their position as varieties of the rather vague Brocton system. It will be less confusing if the following names are employed: The Brocton horizontal arm system and the Brocton high renewal system.

The "Brocton horizontal arm" system is much like the horizontal arm spur system figured on page 540; the chief differences are the absence of spurs and the greater length of cane in the Chautauqua method. The arm, however, is retained practically as long as in the horizontal arm spur system. The spurs are almost entirely dropped, for generally a sufficient number of canes can be found growing from the arm to supply the necessary number of buds. These canes spring directly from the old arm which is fastened along the lower

wire, and they are cut long enough to reach a few inches above the upper wire of the trellis. Each year the canes of the preceding season are entirely removed, being cut close to the arm, and others are put up in their places. Spurs can not be entirely avoided, for the necessary amount of wood might not always be available; they are, however, employed as little as possible.

The "Brocton high renewal" system is plainly different from the preceding. The system has for its foundation the high renewal system illustrated on page 513, but it has developed into a more intricate method on account of the greater amount of wood retained. (See fig. 141.) The number of canes put up is generally from four to eight, and these are cut sufficiently long to reach just above the top wire. These canes are taken from as near the center of the head of the vine as possible, as is done in the ordinary high renewal system, and the number of short arms and spurs is reduced even to a greater extent than in the latter system. In fig. 162 the origin of the canes may be clearly distinguished; they may spring from wood that is from two to several years of age. The principal test as to the desirability of a cane is not so much whether it originates from this or that kind of wood, but rather if it is strong, healthy, and properly matured throughout its available portions. For a detailed discussion of the renewal of these canes, see under "Renewal."

Many vines may be found in the Chautauqua vineyards in which these two systems appear to approach each other. Some vines have rather short arms, which are nevertheless permanent, and others have them reduced nearly to the dimensions of branches. The short arms are very often found upon the lighter soils, or where the plants have been too closely set. These gradation forms are treated practically the same as the types in regard to methods of renewing, pruning, tying, etc.

In pruning, or "blocking," the vines trained upon either of the Brocton systems the process is practically the same as described elsewhere. The number of buds which the vine is to carry is first estimated. Then the number of canes necessary to supply the buds is determined; and the next step is the selection of desirable canes and their pruning at the proper point. After the vineyard has been "stripped," the vines are seen to consist of stems, arms, branches, and spurs, and of loose canes. The canes must now be tied to the wires. Formerly this was done by means of willow twigs, but since 1894 the use of wire for this purpose has steadily increased. The wire is applied as follows: The top of the cane is pressed away from the operator against the top wire of the trellis; the tying wire, which should be a piece of annealed No. 18, about 4 inches long, is now placed with its center against the cane in a direction parallel with the trellis wire, but a trifle above it; with the two thumbs, one on each side of the cane, the tying wire is bent forward and downward; the forefingers of each hand now press

it still farther down and then bring it backward so that the thumbs may again press it upward and over the wire in the position shown in fig. 147. This tie is extremely firm, and, as there are no growing parts beyond it, there is no danger of girdling the cane. This method is to be commended for its cheapness, rapidity, and efficiency; nor do the wires present any serious obstacle to stripping the vines. If other parts of the vine require tying before the growing season, soft twine or willow may be used; such ties should, however, be made loose, else the free flow of sap may be obstructed.

Summer tying of vines trained according to the Brocton systems is entirely avoided. The shoots are allowed to grow as they will. They generally find some support in the form of wire, canes, or other shoots before much damage is done by wind or rain, and thus a great expense is avoided. It is true that the vines do not always present as neat an appearance as might be desired, but in other respects the systems have much in their favor. The fruit is well distributed, well supported, and the difficulties of pruning and tying are reduced to a minimum.

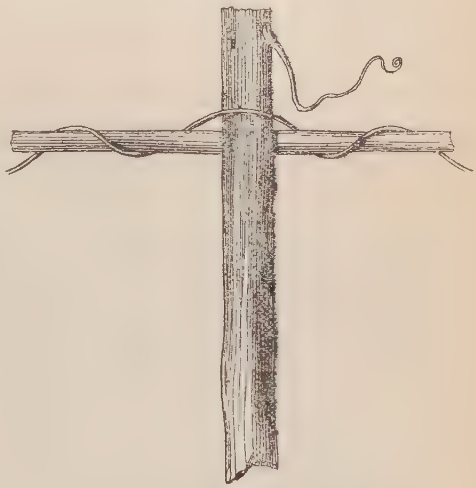


FIG. 147.—The Chautauqua vine tie.

The trellises built for the Chautauqua vines have a few distinguishing characteristics. The posts are made long, especially upon rich soil, so that they stand frequently over 6 feet in height. The lower wire is placed about 30 inches from the ground, the second from 24 to 30 inches above this. In case three wires are used, which is not very commonly done, an interval of about 2 feet is left between them, bringing the upper wire about 6 feet from the ground. No. 10 wire is a good size to use where the growth is heavy, especially at the top.

THE GUYOT SYSTEM.

This system has some of the features of the post and of the high renewal systems. During the first two years the plants are grown as for the horizontal arm system. At the beginning of the third year, one cane is spurred back to two buds, the shoots from these buds being trained upright to a post. The other cane is cut from 2 to 4 feet long, and is then laid down along the lowest wire. The shoots from this cane are trained upright to the second wire. Only two wires are commonly used, and these are supported by stakes, one of which is driven

into the ground at the stem of each plant. At the close of the third year the horizontal arm and its canes which bore the fruit are entirely cut away; one of the upright canes is now bent down to replace the fruiting one, and the other upright cane is cut back to two buds. This process is repeated from year to year, the new canes and shoots springing from the spur at the head of the plant. This system is popular in some French vineyards.

THOMERY AND CHARMEUX SYSTEMS.

Many other systems of grape training might be included in this group. The celebrated systems of Thomery and Charmeux, which are well known in Europe, afford interesting examples of systematic grape training. These systems are forms of the horizontal arm spur system; but they are very elaborate methods, in which several tiers of arms are retained, one above the other; much labor and skill are required to grow vines in this manner, and in America such training is not practiced in commercial plantations. These two systems are briefly described under "Renewal," page 539, as they are only used with plants grown upon walls.

(*b*) THE HORIZONTAL SYSTEMS.

The systems of grape training in which the bearing portions of the shoots are regularly disposed in a horizontal position are not so numerous nor so important as are those described under "The upright systems." Nevertheless, some of the systems require description.

A few horizontal arm systems can be found in American vineyards. The line separating this group from others can not be sharply drawn, and for this reason only the more typical methods will be considered. While it is true that many of the shoots in certain post systems maintain a horizontal position (and this applies also more or less to the Brocton high renewal and even to some forms of the pendent systems), yet, in only one or two cases is special attention given to this point. As a rule, this position is naturally assumed by the vines without attention or interference on the part of the grower.

THE ARBOR SYSTEM.

Arbors and similar structures when covered with vines possess many bearing shoots which retain a horizontal position; but as this result is reached without regard to any system, this entire class of grapevines may be omitted from detailed discussion.

An exception, however, should be made in the case of the Scuppernong grapes of the South. These can be most successfully grown only upon arbor-like structures. The vines can not be satisfactorily pruned on account of the excessive bleeding which takes place, and for this reason they are permitted to retain all the growth that is made. If parts are removed by fire, no bleeding takes place.

The most common practice is to carry the stem of the vine 5 or 6 feet high, so that there will be sufficient headroom underneath, and then to let it branch as freely as it will. The vine is grown on a horizontal trellis, and as the area covered by the plant gradually increases from year to year, the trellis is extended, and eventually one vine may cover about a fourth of an acre of land. The trellises are generally made of posts of the necessary height and upon them a framework is built; old boards, poles, etc., are laid on this. Such a trellis is cheap, and it serves its purpose well.

A continuous arbor system is now in use to a limited extent in the Hudson River Valley. Figs. 148 and 149 show plainly the general plan of this unique system. The stem of the vine is carried upward to a distance of 6 or 7 feet, high enough to allow cultivation underneath

FIG. 148.—The continuous arbor system, unpruned vines.

with a team. A number of spurs are retained at this point, and from these the desired number of canes is obtained. In the vines illustrated in fig. 149, the number of canes left upon each plant is four or five; each cane carries from six to eight buds, so that the total number of buds per plant will be from twenty-five to thirty-five. Fig. 148 shows in what position the bulk of the fruit is borne. The shoots extend horizontally across the trellis, and although some tying is necessary to distribute the pruned canes early in the season, the vines require but little further attention.

The advantages and disadvantages of this system are apparent. The pruning of the vines is difficult, as the canes are so high above the ground that the operator must stand upon some support in order

to reach them. Stripping, tying, and harvesting are also done under difficulties. But, on the other hand, the summer work is light, the shoots are well distributed, allowing the free entrance of sunlight and air, and the fruit is well protected from injury from high winds and other causes which tend to injure or disfigure the berries; in fact, the fruit grown in this manner is exceptionally fine.

The rows of posts are placed 8 or 9 feet apart, and the plants may be set equal distances in the rows. Two vines are grown in the interval between the posts. The wires, of which there are four or five, are fastened at regular intervals to the crosspieces which extend from the top of one post to the one opposite in the next row. Every alternate

FIG. 149.—The continuous arbor system, pruned vines.

space between the rows remains uncovered, as one arbor supplies support for two rows of vines.

THE CROSS-WIRE SYSTEM.

The cross-wire system is another method of training which appears to be confined in this country to the Hudson River Valley, and even there it is used only to a limited extent. But at Jurançon, Basses-Pyrénées, France, this system is regularly followed. Poles are used in place of the wires, however. Fig. 150 represents vines trained in this manner. The stem of the vine is about 7 feet long, as in the preceding method. At its summit are the branches and spurs, but the number of canes annually retained upon them is only four. One cane is tied to each of the wires which extend in four directions from the post to which the stem of the vine is fastened. The posts are

set at intervals of 8 or 9 feet each way, and two wires which cross each other at right angles are fastened at the top of each post. This system does not, strictly speaking, belong to this group, for with some varieties the bearing shoots are mostly pendent, although with others many follow the wires and thus continue in a horizontal direction. Its general features, however, so closely resemble those of the continuous arbor system that the two are placed together. The advantages

FIG. 150.—Cross-wire system of grape training.

and disadvantages of the two systems are practically the same, and although vines trained according to each method may be found in the same vineyard at Marlboro, N. Y., neither has proved to be sufficiently superior to the other to cause one to be abandoned.

THE OVERHEAD KNIFFIN, OR CAYWOOD, SYSTEM.

The overhead arbor Kniffin, or Caywood, system belongs to this group, as the bearing portions of nearly all the shoots remain in a horizontal position. (For a discussion of the true Kniffin system, see

page 529.) The system is plainly intermediate between the two preceding forms, as shown in fig. 151. Tall posts alternate in the rows with the vines, and near the top of each post is firmly fastened a crosspiece which serves as a support for the wires. This piece is about 3 feet in length, and about 6 feet from the ground. Two wires are fastened to it, one at each end, and a third is fastened to the post. Thus, there is formed a three-wired horizontal trellis which extends the length of the rows. The head of the vine is just underneath the central wire, and from this point the canes radiate. Fig. 152 represents the top of an unpruned vine, while fig. 153 shows the same after pruning. The canes are taken from the short arms and branches which form the head, and after pruning they are fastened in different directions to the vines. The number of buds desired upon the plant controls the number and length of the canes.

It would naturally appear that the shoots which spring from the

FIG. 151.—Overhead Kniffin, or Caywood, system of grape training.

canes would droop and swing free below the trellis. Many of them do eventually assume this position, but the bulk of the bearing wood remains on the wires.

The overhead Kniffin system has several points in its favor. The wood and fruit are mostly out of harm's way, and the ground below is left free for occupation by other crops. Fig. 151 shows how currants are grown between the rows of vines; in such cases, of course, the land must be heavily fertilized to prevent injury to either crop. The disadvantages of the method have already been considered in connection with the preceding system.

THE MUNSON SYSTEM.

The Munson system is a modification of the overhead Kniffin. Instead of using only one post to support the crosspiece upon which the

wires rest, two are set in; these posts are in contact at their lower end, but they diverge so that at the top they are about 3 feet apart. A wire is stretched along the upper ends of each of these two rows of posts, and between them, but somewhat lower down, a third one is placed. It is held in position by a wire which is swung between each pair of posts, and which takes the place of the crosspiece in the overhead Kniffin system. These three wires therefore form a V-shaped trellis, upon which the vines rest. As in the preceding system, the head of the vine is just below the middle wire, and is fastened to it; but the number of buds is distributed among only two to four canes, and these are all fastened to the central wire, and not to all the wires of the trellis. The bearing shoots at first grow upright, but they soon bend over, and many of the growing tips hang down from the outer wire. The bearing portion, however, remains practically horizontal.

The only summer pruning that is practiced is to pinch off the ends of the bearing shoots after the plants have blossomed. Summer tying is also avoided, the shoots being pulled down so that the growth beyond the bearing portion may be pendent.

FIG. 152.—Unpruned vine trained on the overhead Kniffin, or Caywood, system.

The canes which are each year retained are selected in much the same manner as described for the high renewal system (page 513). A similar method is followed in the overhead Kniffin, as well as in some of the systems mentioned in the pendent group.

THE CRITTENDEN SYSTEM.

The Crittenden system is successfully followed in a few vineyards. It is practically the same as the overhead Kniffin system, but differs essentially in the height of the posts. One post and crossbar bear the three wires. The posts are scarcely over 4 feet high, and the wire trellis in some cases is not much more than 3 feet from the ground.

The vines fall freely over the side wires, frequently making a very dense shade under the trellis; this is of course undesirable on account of the favorable condition for the development of disease.

Prof. Hugh N. Starnes, of the Georgia Experiment Station, writes that one of the most promising systems for the South is one which combines certain features of the two preceding systems. Only one post is used where two are set according to the Munson system. Across the top of this post a crosspiece is fastened, and from this three wires are run the length of the trellis. These wires are placed in the form of a V, and they are carried 6 or 7 feet above the ground. The canes which produce the bearing shoots are all trained along the central lower wire, in which respect this system differs from the overhead Kniffin as generally followed.


FIG. 153.—Pruned vine trained on the overhead Kniffin, or Caywood, system.

HUDSON HORIZONTAL SYSTEM.

This typical form of horizontal grape training may be found in a number of vineyards situated near the Hudson River. Figs. 154 and 155 illustrate the system clearly. The stem of the vine is about 15 inches high; from its upper part a cane is carried to the top of the trellis, and then it is bent toward one side and tied to the top wire of the trellis, as shown in fig. 155. It is made so long in order that the plant may be supplied with a proper number of buds. The trellis carries only two wires, the lowest being about 2½ feet from the ground; the top one about 3 feet above the first. These wires are not designed to bear directly the weight of the vines, but slats are fastened to them, and these slats support much of the weight of the fruit and foliage. By examining fig. 154 it will be seen that one slat, a lath being commonly used, is placed on each side of the vine, and about a foot from it. The lath is stapled so that only a few inches project below the lower wire, while about a foot extends above the upper.

As the shoots in early summer become long enough to allow of their being tied to these upright slats they are so fastened as to be held in practically a horizontal position. Frequently two more slats are used, one being placed about 12 inches from each of those at first put

on; eventually the shoots are also tied to these; such upright pieces should be considered as forming an integral part of the trellis. They are firmly stapled to the wire, and remain there until they decay or become broken.

The head of the vine shown in fig. 154 is of especial interest, since it shows the method by which almost the entire bearing portion of the vine was girdled. Below the girdled point are three canes, which served to supply the roots with nourishment, and one of them (in this case the lowest on the right-hand side) will be used in forming the new top, as shown in fig. 155; the rest is nearly all cut away, only sufficient wood being left to supply new shoots near the top of the stem, as had previously been done.

FIG. 154.—Unpruned vine trained according to the Hudson horizontal system.

Modifications of this system are found both in American and European vineyards. In the Hudson River Valley the vertical slats are sometimes absent, but two or three extra wires on the trellis answer the same purpose. As the shoots from the upright cane develop, they cling to the wires without the aid of summer tying, or at most but very little of this work is done. The shoots in consequence do not assume a perfectly horizontal position, but they ascend at an angle of about 45°. The bearing portion of the vine is renewed each year.

In several of the large vineyards of the Médoc, near Bordeaux, France, a system is found that is similar, in many respects, to the Hudson system. The one essential difference is that the upright cane is there permanent, and it forms a vertical arm, or cordon, which is spurred from each side, the spurs being kept as short as possible. The shoots which annually grow from these spurs are fastened horizontally to the wires of the trellis, the number of wires varying from

four to six or more, as the vigor of the plants may require; the distance between the wires is from 12 to 15 inches. This system is equivalent to a vertical cordon, a form which is commonly used on walls and in certain greenhouses. It has also been termed an "upright stock with alternate spurs," the description of the system being fairly well included in the name.

THE LOW HORIZONTAL SYSTEM.

Médoc espalier, or the low horizontal system of Bordeaux, France, is one which gives excellent results upon certain light soils of that famous region. The stem of the vine is not more than 10 or 12 inches in height (fig. 156), and at its summit are two short arms with spurs. The canes are cut back each year to one or two buds, and the shoots which grow from these are trained horizontally, one or two on each side of the stem, to a strip of wood or to a wire which extends along the rows at a distance of only 15 or 18 inches from the ground. A post is ordinarily placed midway between the adjoining vines of the same row, and the horizontal supports are fastened to them. When the shoots have grown so long that they reach these posts, the growing tips are pinched off; this forces many of the axillary buds of the shoots into growth, and when these laterals have grown about a foot they are in turn pinched back, so that the fruit may receive as large a supply of sap as possible. The instruments used for this summer pruning may be an ordinary knife, pruning shears, or some other convenient tool; a sickle-shaped blade is very often used in France, especially for cutting the upright standing laterals. In the Médoc espalier the grapes are borne near the ground, and this is supposed to have a very beneficial effect upon the quality of the fruit; the temperature surrounding the berries is said to be higher, both in the daytime and at night, than is the case with grapes borne upon higher trellises. Some of the finest and most expensive wines of Europe are produced from grapes grown in this careful and painstaking manner, for the yields per acre from such vines are not very large. This system is also employed upon soils which require larger trellises, but the general plan remains the same.

FIG. 155.—Pruned vine trained according to the Hudson horizontal system.

THE ANNIS SYSTEM.

Probably the system which is adopted in Annis, Lower Charente, France, brings the shoots nearer to the ground than results from any other horizontal training. The canes are each year cut back severely,

and as they are borne upon branches that rest almost upon the surface of the soil the new growths start from a very low elevation. These shoots are not tied upright, but they spread out horizontally, occupying a circular area which may be from 3 to 5 feet in diameter. As a rule, they are not supported so as to keep the foliage and fruit above the surface of the soil; and they have therefore sprawled in all directions. In certain seasons such treatment is followed by serious injury to the fruit, and many losses have resulted. The system has little to commend it, except the almost total absence of labor as regards training.

GRAPE TRAINING UNDER GLASS.

The majority of the systems adopted for training grapes grown under glass and upon walls belong in this group, but as this subject forms such a natural and separate group it will be treated independently of the other systems (see page 531).

(c) THE PENDENT SYSTEMS.

The systems included in the third group probably approach the natural growth of the vine more closely than is the case with those found

FIG. 156.—The Médoc espalier, or low horizontal, system of Bordeaux, France.

in either of the other two groups. The shoots are suspended from some support, and, if unattached, swing freely in every breeze that has sufficient power to stir them. Their direction of growth is downward, and if they succeed in fastening themselves to some fixed object the fruit is firmly supported; this insures protection to the crop, just as effectually as when the lower or growing part of the shoot is free, for in neither case can the clusters be whipped by winds against any resisting object, which is a very common source of loss. The yielding nature of the shoots insures the safety of the fruit.

Another apparent advantage of the pendent systems is their tendency to check the growth of all varieties. In upright-growing plants the heaviest flow of sap is generally toward the highest parts; even the outer buds of a horizontal cane make the strongest shoots. But if the end of the cane is bent downward so that the entire cane is more or less sharply curved the growths from all the buds will be very uniform. The vigor of a shoot may also be affected by changing the direction of its growth. When a tip of the shoot is ascending, the most rapid growth takes place; but when the same shoot is bent over

so that it becomes pendent its vegetative activity is reduced from two causes—a certain amount of constriction is produced when the bending takes place, and the flow of sap ceases to be so strong merely on account of the position of the shoot.

It is also asserted that the grapes grown by a pendent system are larger and handsomer than when produced by other methods. Considerable truth may exist in this belief, for the bending of the shoot may have an effect similar to that produced by girdling, only it will be less marked; and it is well known that girdling a vine causes the berries to become larger and to ripen earlier.

Yet, in spite of the above favorable qualities, the drooping or pendent systems have not become very popular either in Europe or in America, although their essential features have long been known. That these methods have not proved successful upon poor soils or with weak-growing varieties may easily be explained by the fact that as strong a growth as possible is desired under such circumstances, and no system which materially checks the development of the shoots can prove profitable. At least such has been the experience in America, and the vineyards of Europe would seem to indicate that the same is true there also, for with scarcely an exception the vineyards upon poor soils are trained in some upright system.

Upon strong land and with vigorous varieties, the pendent systems are giving excellent results in various parts of this country; in fact, they are used in some sections almost exclusively. But, on the other hand, other districts which possess apparently the same land and varieties report the systems as total failures. One trouble in such cases probably lies in the fact that the pendent systems are not thoroughly understood; that too much weight is placed upon the statement that such training reduces the total growth of the plants; and that the quality of the fruit has not been improved sufficiently to counterbalance the loss caused by more severe pruning.

Theoretically, it would seem that the more abundant the natural growth of vine the more are the pendent systems to be recommended. Yet, in changing to these forms it is well to keep in mind that the same soil is still to be dealt with, and also the same varieties of grapes; therefore, approximately, the same quantity of wood will be produced whatever be the method of training adopted.

The pendent systems should consequently be so modified that each vine will still bear, when pruned, about as many buds as were allowed under the old method. Otherwise disastrous results must follow, and further, all changes from one system to another should be made gradually, so that the grower may at all times feel that he holds the key to the situation; he should make no radical change without realizing fully the effects which in all probability will result.

America is the home of the pendent grape systems, for, although Europe has a few representatives of the group, they are of such minor importance that no mention need here be made of them. It is in this

country that the use of the systems began in commercial plantations, and here they have reached their highest development. At present they appear to be gradually growing in favor, although as yet the men who have adopted them exclusively are comparatively few.

THE KNIFFIN SYSTEM.

The best known form of the pendent group is the Kniffin system, and nearly all other forms may be considered as modifications of it. Concord, Niagara, and similar vigorous varieties have been very successfully trained in this manner. The plants are set 8, 9, or 10 feet apart each way, as is done in common practice. The treatment given the young vines will be better understood if the type of the system is kept in mind. Fig. 157 represents a pruned vine trained on the true Kniffin system, and this is the form desired for the plants of the newly set vineyard.

Fig. 157.—Pruned vine trained on the Kniffin system.

The first year the young vines are allowed to lie upon the ground, but the second year steps must be taken toward forming the permanent top. When the vine is pruned in early spring, only about two vigorous buds are allowed to remain, and if one strong shoot is obtained that is all that is necessary. These shoots are trained to long upright stakes, so that the matured canes may be in the position of the permanent stems; a trellis is not necessary the second year, although it sometimes occurs that the vines grow so vigorously that the top may be formed the second summer instead of the third.

At the beginning of the third year the vines are pruned ordinarily, so that the one upright cane extends to the top wire of the trellis, and possibly one or two laterals may be present, but these are of minor importance. The principal object should be to get a strong, well-matured, upright cane. Some growers do not carry this cane to the top wire the third year, but prune it down to the second; the fourth season, however, a cane is tied to the top wire. Although the vine shown in fig. 157 has but one stem, some vineyardists prefer to have two, as it is said that the growth upon the top wire will take place at the expense of that on the lower. How much truth there is in this statement has not been shown, but in actual practice the stem of the

vine is frequently branched near the ground; one branch goes to the first wire, while the other extends to the upper one. This division of the stem should, of course, be made the second season by allowing two shoots to grow from the pruned vine.

The trellis should be in position before the beginning of the third season's growth. Posts, wires, etc., are used as already described, but the wires are differently arranged. Only two are used in the true Kniffin system. The lower one is placed from 3 to 4 feet above the ground, and the second from 2½ to 3 feet above the first. Some fruit may be borne the third year, but too much should not be allowed to remain. When the vine is pruned at the beginning of the fourth season, it may be shaped so as to resemble the one shown in fig. 157. All laterals except four should be removed from the main stem. Two of these should be near the top wire and two near the lower. Their length will depend upon circumstances, but generally the upper two are cut longer than the others on account of the stronger growth at the upper part of the vine. When the capacity of the vine has been estimated and the number of buds to be left is decided upon, then the length of the canes may easily be determined. In fig. 157 each of the upper canes carries six buds and each of the lower four buds, making a total of twenty. A proportionate distribution may be made in other cases.

The canes are tied to the wires before growth begins in the spring, and thereafter the plants will almost entirely take care of themselves. The young shoots will at first be upright, but later they bend over and become pendent. Summer tying is wholly unnecessary, and all that is required is to go through a vineyard to pull down such shoots as have started to grow along a wire instead of hanging downward from it. Even this work is often neglected, but it is not advisable to do so.

Summer pruning is also done to a limited extent. When the shoots which hang from the first wire become so long that they interfere with cultivation, they are frequently cut back with a sickle or similar instrument, and those from the top wire may be severed in a similar manner if they shade the lower growth too heavily. Such pruning is very rapidly performed.

After the fourth season the vine retains essentially the same form from year to year. The plant in fig. 157 was over twenty years of age when photographed, and, although crooked and gnarled, it has still the same outline that was given it many years before.

The umbrella, or two-cane Kniffin, is an important form belonging to this group. All the distinguishing features of the true Kniffin system are present, with the exception that only two canes are left instead of four. (Fig. 162.) These canes are also cut longer, since the same number of buds must be retained on the plant to prevent the too free production of wood. The lower canes are cut away; the upper ones, each carrying from ten to fifteen buds, are first tied to the top wire,

after which they bend downward until they reach the lower wire, when they are again tied. The appearance of the plant when so trained has given rise to the term "umbrella system," which very appropriately designates the method. The general treatment of the vine in other respects is the same as that described under "The Kniffin system."

The one-wire Kniffin system is used by few vineyardists. The plant is pruned down to two canes, and these are tied on opposite sides of the plant to the single wire on the trellis. The canes carry from eight to twelve buds each. The wire is from 3 to 4 feet above the ground, and this allows abundant room for the shoots to sway in the wind. Cheapness and ease of management are claimed for the system, but it can not be very successfully used except upon lighter lands or with weak-growing varieties.

Six and eight cane Kniffin systems have been described by writers, but they are little used.

THE SINGLE CANE RENEWAL SYSTEM.

The single cane renewal is a peculiar form of the pendent group which is employed in certain parts of Massachusetts. Post and wire trellises are used, the lower wire being from 2½ to 3 feet from the ground, and the second from 2 to 2½ above the first. The head of the vine is at the lower wire; each year a cane springing from it is carried to the upper wire and extended until it reaches the adjoining plant, the distance between the vines being 6 or 8 feet. All the fruit is borne upon the shoots which spring from the fifteen or twenty buds upon the cane. These shoots are pendent and are pinched at a point two or three joints below the lowest cluster of fruit. As laterals are produced, these are again pinched just beyond the first or second expanded leaf. This operation may be performed three or four times during the summer. The fruit at the same time is thinned to one or two clusters to each bearing shoot. A single shoot is also grown from the head of the vine and trained on the opposite side of the plant upon the lower wire. This shoot is matured into a cane which is the following year trained to the upper wire and allowed to bear as described.

The above system has been modified by growers. One of the most radical changes is one in which the bearing cane is placed along the lower wire instead of the upper. The bearing shoots are then trained upright and fastened to the second and third wires, there being three of these, as in the high renewal system. The next year the cane on the opposite side of the plant bears. In this manner only one-half of the vine bears each season.

WALL AND GREENHOUSE SYSTEMS.

The methods of training grapes on walls and in greenhouses are peculiar. Although nearly all these systems may be classed in the group having horizontal bearing wood, a clearer idea of the various

forms may be obtained by treating them as a group especially adapted to culture under glass.

A much smaller number of systems have been described in this group than in any of the preceding, and another peculiarity should also be noted, that is, that nearly all writers who consider the training of grapes under glass hold strong views as to which system is the best, each advocating, as a matter of course, the method he follows. Under such circumstances it is impossible to say which is absolutely the best system. The methods with which a certain gardener may be familiar will undoubtedly give better results in his hands than will any with which he has had less experience, and herein probably lies the secret of some of the unqualified preferences which may be found among growers. A novice must therefore select the one or more systems which appear to meet his requirements most fully, and then by actual practice determine which, if any, gives the best results. Unquestionably one grower may obtain most satisfactory results from a system which in the hands of another is followed by indifferent success. At present there is but little choice that may be based upon purely theoretical grounds. Experience has weeded out nearly all systems except those named below; these may be considered as the "survival of the fittest," and all are worthy of trial.

Considerable difficulty has been experienced in selecting proper names for the various systems, for many different names have been used to designate systems which are practically identical; many unnamed descriptions have also been published. To avoid confusion only the most common and the most suggestive ones have been retained.

All wall and greenhouse systems have been divided into two general classes, the spur and the rod systems; they are not very sharply defined. The typical spur systems are much more popular than the others, although strong advocates of the rod systems may be found.

THE SHORT SPUR SYSTEM.

The short spur system is the simplest form of the class in which all the canes are cut back to short spurs. The formation of the main stem as here described will also answer for the other systems of the class. In spring or autumn, a rooted cutting one or two years of age is planted in the border of the greenhouse or in one adjoining a wall. The plant should be cut back to two or three strong buds. As growth commences, only the strongest of the shoots produced by the plant is retained, the others being removed as soon as their comparative value is noticed. The one remaining shoot is trained straight upward, and it may be allowed to grow unchecked throughout the season. The laterals which spring from the buds along the lower portion of the shoot are generally pinched to one leaf to check their growth. When the vine is pruned, they are entirely cut away, although some growers remove the laterals first pinched when those next above are

stopped. In this manner the other buds found upon the cane are prevented from growing.

The pruning of grapes grown in houses or on walls is almost invariably performed as soon as the crop has been removed and the wood is well ripened. This clears the houses of all superfluous wood and allows the vines, trellises, etc., to be thoroughly cleaned. The storage and protection of the tops during winter are also made easier; and in case the house is to be used for other purposes during the winter or spring months there is no useless brush to interfere.

At the end of the first growing season the vine should therefore be pruned, but different operators do not agree as to the proper amount of wood to remove. Some cut back the year's growth to a spur, leaving three or four good buds, as is done in regular vineyard practice. The following year the strongest of the shoots from these buds is selected for forming the main stem; the other shoots are repeatedly pinched to keep them short, and they may be allowed to bear one or at most two clusters to each vine. By this method the vine is prevented from bearing a crop the second year, and all danger of weakening the plant from this cause is avoided.

The majority of growers prefer to leave the first year's cane from 4 to 7 feet in length, according to the vigor of the variety. All laterals and also the tendrils are removed. In addition to this, the buds which are to form the future spurs must also be selected and the remainder cut away. If the cane produced the first year is spurred back to three or four buds, as already described, the vine will not be ready for this disbudding process until the end of the second year. The buds may then be cut out, but as the number and position of those retained in either case vary somewhat with the system of training adopted, the method of their selection will be separately considered under each system. But the terminal bud must in all cases remain to lengthen the stem the following year.

The trellises used for training vines in greenhouses are of various kinds. They generally consist of a firm wire support, which is suspended from the rafters of the building at a distance of 15 to 18 inches from the glass. Cast-iron hangers are fastened to the rafters, and the main wires pass through holes in the lower end of the irons. (Fig. 158.) Frequently only one set of wires is employed; in such cases the wires may run from the plate of the house upward to the ridge pole, or, more rarely, they may extend horizontally across the house. But additional supports are necessary when the plants are fruiting. Fig. 158 shows two vines whose spurs are supported by five vertical wires, but, in addition to these, slender sticks have been fastened across the wires, and these serve to distribute the weight of the foliage and the fruit more evenly, and also make the wires more rigid. Such a trellis also allows the pruned wood to be removed more freely in the fall. Another good form of trellis is made by letting a No. 10 or No.

12 wire run upward over each vine; the main stem of the plant is then trained permanently to it. Cross wires of smaller size, as No. 16, are then stretched lengthwise of the house, being placed about 18 inches apart, and fastened to the upright wire at the intersecting points. Such a trellis is suitable for all methods of training considered in their group, although in special cases, as in the rod systems, certain modifications may be advisable.

The short spur system is a simple and well-known method of training grapes, although many growers are opposed to its use. After the vine has been grown so that it is ready for the first disbudding, the positions for the future spurs must be decided upon. As a rule, spurs are grown from buds left at intervals of 15 to 18 inches along the sides

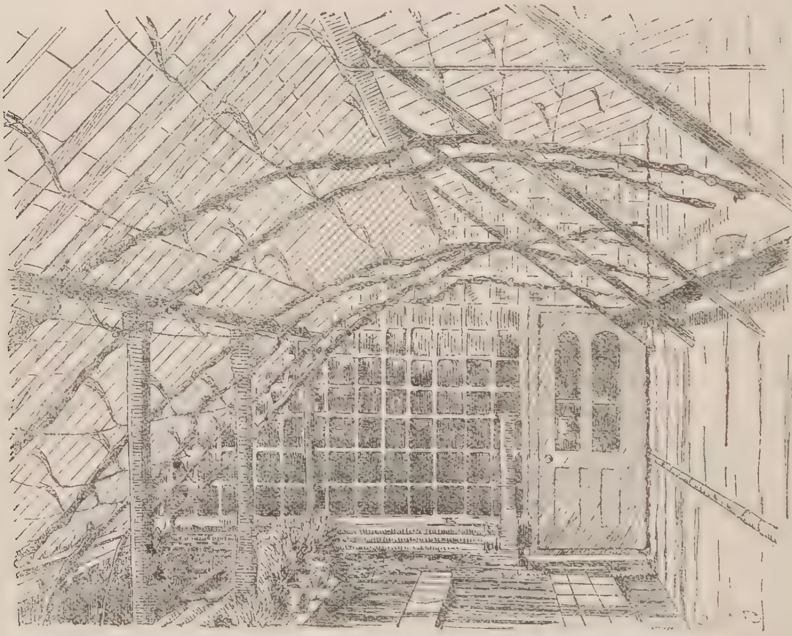


FIG. 158.—Grapery, with vines trained according to the short spur system.

of the stem; sometimes the spurs are nearly opposite each other, and again one spur may be situated midway between or about 10 inches from the spurs on the opposite side of the stem. After the selection of the buds that are to remain, the others may be cut out immediately or they may be allowed to swell during the following spring, when they are destroyed by severe pinching. The shoots that grow will bear fruit if they are allowed to do so; it is much better for the plant, however, to cut away all clusters except two or three, since, if a vine is made to overbear when it is young, years are often required for it to return to its normal vigor. When these shoots have grown to a length of six or eight joints, the ends are pinched off; laterals will start, especially near the end of the pinched shoots, and these, in turn, should be

checked. In this manner strong, well-matured wood is obtained without an excessive growth. The next year the vines are treated in the same manner. The terminal bud of the pruned cane is carefully grown along the supporting wire so as to extend the stem from 5 to 7 feet more. The laterals are treated as already described. The third year the stem may be carried to the top of the grapery.

Vines which are trained on the short spur system, as well as those grown according to some other methods, are commonly not allowed to bear fruit except upon one-half of the spurs. This may bring about a difference in the length of the two sets of spurs upon each plant. Those which are to bear are often cut to a strong bud, there being one or two other buds near the base of the spur. The other spurs are cut in close to the stem, only one bud being left. This bud is destined to form a shoot which will be spurred the following autumn for fruit-producing purposes; it is not allowed to fruit the first year. The plump bud left upon the fruiting spur is the one from which the fruit is expected; after the fruit has matured, the old spur may be cut away entirely, and only one bud is allowed to remain upon a shoot which grew either from another bud upon the same spur or from some other part of the branch. Even the fruiting spur is often made as short as the other, thus not exceeding an inch in length. Fig. 158 represents a grapery in which the vines have been trained according to the short spur, or "walking-stick," system; the vines have been pruned and are ready to be put away for the winter.

SPUR RENEWAL.

Another method, very similar to the one just mentioned, is sometimes practiced for the purpose of obtaining fruit from the same spur each year.

The spurs are each year cut back to two or three buds. The outer or most plump ones are retained for fruiting purposes, the weaker one being removed as soon as the difference of strength is demonstrated. The other bearing shoot is pinched one or two joints beyond the fruit, and securely tied; as laterals appear, they, in turn, are pinched just beyond the first unfolded leaf. The remaining bud is situated close to the base of the spur; it is designed for the production of a shoot only, no fruit being allowed upon it, and it is not pinched until it has unfolded six or eight leaves. The following autumn this shoot is, in turn, cut back to two or three buds, the bearing portion of the old spur being all cut away.

THE DOUBLE SPUR SYSTEM.

The double spur system is very commonly used in graperies (fig. 159). The vines are started and the first year spurred as already described. Two shoots are retained upon each of these spurs, one of them perhaps being allowed to fruit. The next year each shoot is cut back to a plump bud, thus forming a Y-shaped piece. Only one of these spurs

is allowed to bear, the other serving only for the production of bearing wood for the following year. In this manner each branch gradually elongates and bears fruit in alternate years. Fig. 160 shows such a double branch, of which the left-hand portion is 6 years old.

THE LONG ROD RENEWAL SYSTEM.

The long rod renewal system is another form which has several features that commend it for use in graperies. Short spurs are not used for bearing purposes, but in place of them the canes are cut so long that the bearing portion is as long as one-half the height of the grapery. The plants are obtained as follows: At the end of the first season's growth the first cane, obtained as already described, is allowed to extend about half the height of the building or wall. The second summer it is allowed to bear, and it is also extended to the top of the roof, at which point it is pruned in the fall. During the second year another shoot is grown from the stem near the point where the first cane originates. In the fall this is pruned in the same manner as the first was the preceding year. The third year the upper half of the first branch bears, and also the second one throughout its entire length; at the same time a third shoot is grown from near the bases of the first two. The pruning which is done in the fall of the third year is the same as that which regularly takes place from this time on. The first branch is entirely removed; the second is cut at the top of the grapery, and the spurs on its lower half are all cut out; the third is pruned at only one-half this height. Thus, each year a

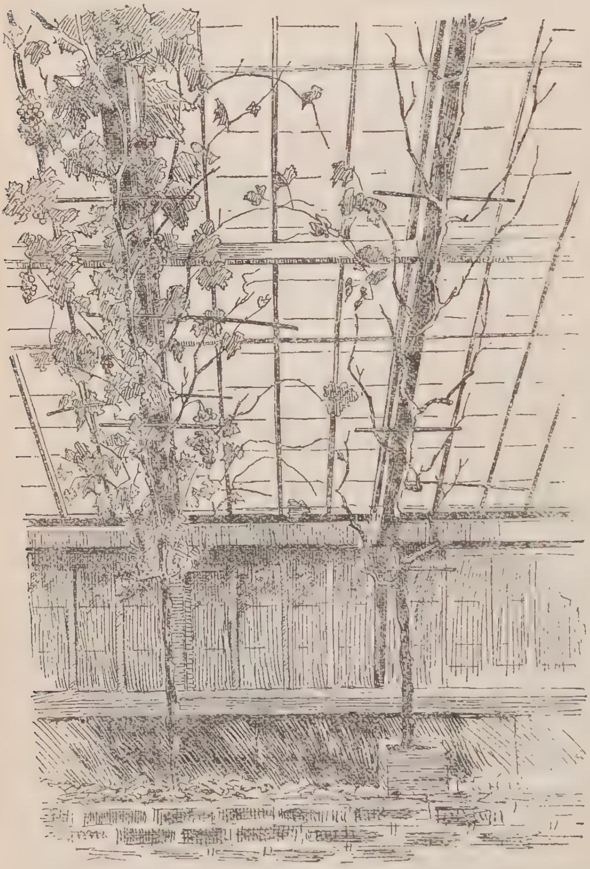


FIG. 159.—Grapery, with vines trained according to the double spur system.

large portion is removed, no cordon is allowed to become more than three years of age, and good buds are always available for fruiting purposes. All bearing shoots should, of course, be pinched at the first or second leaf beyond the cluster of fruit, and if the shoots produce laterals these should be pinched in a similar manner.

Plants trained on this system require a little more space than when spurs are used, but if the vines have been set about 3 feet apart, two branches may be used instead of three. This method was formerly much used. By it one half the top was removed each fall, the other portion being reserved for bearing the next year.

The height of the stem in the long rod renewal system varies under different circumstances. Under glass it may be carried up to the glass, so that all portions of the branches may receive good light. If the vines are trained to a wall equally well lighted from top to bottom, the stem need extend but a few inches above the surface of the ground. Renewal may take place in accordance with the methods described elsewhere.

FIG. 160.—Branch and cane of vine shown in fig. 158.

THE LONG SPUR SYSTEM.

The long spur system has many features which characterize the horizontal arm spur system described on page 508. Plants grown on walls are frequently trained according to this system or modifications of it, and it also possesses a certain value on an upright trellis. The stem, arms, and spurs are formed as in the horizontal arm spur system, although the arms, or cordons, are sometimes upright instead of horizontal. In either case, only alternating spurs are allowed to carry fruit in any one year. For instance, the first, third, and fifth spurs on an arm are cut long enough for each to carry from four to seven buds, according to the vigor of the plant. These buds are allowed to produce fruit. But the second, fourth, and sixth spurs are cut much shorter, bearing only one or three buds; these buds will not be permitted to mature any fruit, as their entire office is to produce wood which will bear the following year. Considerable attention is necessary to grow plants properly in this manner; still it is frequently done.

When it is desired to cover a considerable area in a grapery with but one vine, the method following may be adopted with success.

The vine is started as for the horizontal arm spur system, but several tiers of arms are made. Each arm has a certain number of spurs, which are renewed and made to bear each year according to the spur renewal method described further on. In this manner, by having a considerable growth of foliage in all parts of the vine, bare places may be almost entirely avoided and uniform crops annually obtained. The utmost care and attention must be exercised to make the system a success, for the strong tendency toward growth in the upper parts of the vine must be overcome by continual pinching of the shoots.

DESCRIPTION OF THE THOMERY AND CHARMEUX SYSTEMS.

The difficulty of growing grape vines in accordance with the above system has led to the origin of the Thomery and Charmeux systems. These are intricate, but their essential features are as follows:

No one vine shall have more than two horizontal arms, one on each side of the top of the stem. If a high and long wall is to be covered, a number of plants are set out and the stems of these are carried to different heights. The lowest pairs of arms are about 6 inches from the ground; the second set of arms is about 18 inches above the first, and this distance is maintained between all the other sets on the wall. Each arm is 4 feet long, and the spurs are grown at intervals of 6 or 7 inches from each other. The method of spurring is the same as that described under the short spur system, for none of the spurs are over an inch in length, and the branches which bear them are consequently always short. Two shoots are grown from each spur, and every shoot is allowed to bear according to the above dimensions; the plants should be set between 21 and 22 inches apart.

In the Thomery system the first plant at one end of the wall forms the lowest pair of arms; the second plant, 22 inches from the first, bears the second pair of arms, 18 inches above the first pair; the third plant bears the next pair above, and so on until the top of the wall is reached. Some trouble has been experienced in the Thomery system on account of an unequal amount of light given the two arms of the same plant. This trouble is avoided in the Charmeux system by a different arrangement of the arms. In other respects the two systems are alike.

The following is the arrangement of the arms in the Charmeux system: The first plant bears the first pair of arms; the second plant has its arms in the fourth tier of arms; the third plant branches in the second tier; the fourth plant extends to the fifth tier; the fifth plant to the third tier. The sixth plant then begins as the first one did, and the same arrangement is repeated.

THE FAN SYSTEM.

The fan system is almost entirely restricted to use upon walls. It is occasionally seen in vineyards, but here it is not very popular,

although found in some portions of Ontario, Canada. In some respects the plants trained on the fan system resemble those described under the high renewal system, but the head of the vine is frequently only a few inches from the ground. The canes which are to produce the bearing shoots spring from the head of the plant, but a greater number are retained. They are trained in a spreading manner from the head, covering a fan-shaped area, which has given the system its name. One serious objection to the system is that so much fruit and foliage are produced near the center of the plant that it is difficult to admit sufficient air and sunshine; a tangle is apt to result. Otherwise, if proper attention is given to spurring for renewal, the system is a satisfactory one.

RENEWAL.

Renewal is the process of replacing old wood by young wood which has the power of performing the functions of the old. All parts of the vine which are above ground deteriorate with age; and the roots may change in a similar manner. Some portions of a vine may remain serviceable for a number of years, and their renewal is consequently necessary only after long intervals; but other parts are rendered useless after one year's service. In order to keep a vine in a strong bearing condition, young wood must take the place of the old whenever it is necessary.

Cane renewal must be performed each year. The shoot which matures into the renewal cane must be grown the season before the old cane is cut out, that the one may replace the other without loss of time. As every vine is presumably grown upon some distinct system, the number and length of the desired canes is always known; some may be shortened back to spurs, while others remain several feet in length.

Cane renewal is a very simple matter in all true spur systems. The bearing shoot of one year is cut back to a very small number of buds, generally from one to three, and this spur is the portion which takes the place of, or renews, a similar spur which the year before supplied the plants with bearing shoots.

In all systems which require long canes for renewal purposes, the production of proper wood to replace the older portion is not generally such an easy task; it is here that experience and judgment are required in making selections. Such canes are obtained from three distinct sources: First, from the base of the canes which produced the bearing shoots of the last season (fig. 161, *a*); second, from branches which are retained especially for renewal purposes (fig. 161, *b*); and, third, from shoots grown from adventitious buds on the arms or branches (fig. 161, *c*).

The renewal canes, which are selected from the base of the canes that produced the bearing shoots, are generally well grown and mature (fig. 161, *a*). It is true that they have borne fruit in the majority of

cases, but this has not been shown to be a serious defect. One objection to them, however, is that a considerable portion of the old cane is retained with the new one, and if this form of renewal is continued for a few years, these branches become so long that the bearing wood may start near the top wires of the trellis, a position in which they are actually found in some vineyards. On this account the continued selection of such canes upon the same branch should be avoided. (See fig. 145.)

A favorable method of obtaining renewal canes is by the use of spurs. These are necessarily situated near the top of the stem, so that the long canes may be easily directed to any desired point. The branches formed by the spurs are, as a rule, not retained many years, for they, in turn, require renewal. Their number varies with different vineyardists; in case all the canes are to be derived from spurs, there

FIG. 161.—Horizontal arm spur system, illustrating the parts of a vine.

should be at least one spur for each cane, and frequently there are twice as many spurs as canes. Fig. 161 will assist in making this point more plain. If one branch is to do double duty by supporting a cane with bearing shoots *d* and also a growing shoot *c*, which is to replace the cane *d* the following year, it resembles more or less closely the spur *b*. After the fruits borne upon the shoots of *d* have been harvested, this old cane and its shoots, as well as all the old spurs down to the cane *c*, are cut away, and *c* is laid along the wire in place of *d*.

Frequently the spur or branch produces only a single shoot, and in

such cases the number of branches must be greater than the number of canes used, so that each branch may alternately support a shoot and a cane with its bearing shoots; this will require twice as many branches as canes. But on account of the various sources from which desirable canes may be obtained, the number of spurs and branches is rarely so great.

FIG. 162.—Unpruned vine trained according to the umbrella system, showing stem renewal.

The third method of obtaining long canes is from shoots which grew from adventitious buds. (Fig. 161, *c*.) These may arise from any of the older parts of the plant, and if they are strong and well matured, they answer the purpose well. As the vine grows older, the appearance of such shoots can not be so safely relied upon as when the plant was young; and even under favorable circumstances the vineyardist should at all times be prepared to get along without them.

Branch renewal is of great importance for all systems in which spurring is regularly practiced. As the branches are formed from annual additions of spurs of varying lengths, they almost invariably become long, crooked, and unsightly, and their removal every six or eight years benefits the plant as well as pleases the eye. A branch may be renewed by selecting one of the strong shoots which appear at irregular intervals about its base, and at the end of the season spurring this shoot instead of one grown from an old spur. The entire branch may then be removed.

FIG. 163.—Pruned vine trained according to the umbrella system.

Arm renewal is accomplished by selecting a strong cane that started from a bud near the base of the arm. This cane may be put in the position of the arm after the latter has been cut out, and the following year its shoots should yield practically a full crop. Under ordinary circumstances, an arm should be renewed when it is eight or ten years old.

Stem renewal can not be wholly completed in one year, as in the

above cases, for an entirely new top must also be formed. If the change is to be made without any loss of crop, the new wood should be grown, for most systems, two years before the old top is cut out. The first step is to select a strong cane which starts near the base of the old plant. This cane is then treated in the same manner as a well-established one-year-old vine; it is cut off at the desired height, and the second year a new top is formed upon it. This top forms the framework of the new vine, and at the end of the second season the old vine may be cut off close to the point at which the new portion originates.

These steps are well illustrated in figs. 162 and 163. A vine trained according to the umbrella, or two-cane Kniffin, system is shown in fig. 162. The main system was about twenty years of age when its renewal was decided upon. Close beside it may be seen a straight, slender stem, which extends upward without branching nearly to the top wire of the trellis. When photographed, it was three years old; at the end of the first year it was cut back to the top wire; after the second year, the two strongest canes at the top were selected to form the arms of the future vine, and they were cut the proper length. The old plant might have been cut out also, but this was not done; the top was severely pruned, however, so that the younger portion might be strengthened. At the end of the third year, when the photographs were made, there were two sets of pendent branches, one from the old and one from the new arms. The old vine was then cut close to the ground, and the pendent canes of the young vine were each spurred to one bud. Fig. 163 shows the result. This young vine with the old roots is capable of producing crops as large as those borne by the old top, and the fruit should be of better quality. In this manner a vine can be made young again, and the process may be repeated again and again.

It is impossible to state when the stem of a vine should be renewed. Records exist showing that some European vines have seen one or two centuries of growth; plants fifty years of age are commonly seen, and it appears almost as if they could continue to grow and bear indefinitely under proper treatment. In American vineyards the stems are renewed more frequently. Twenty to thirty years is almost the extreme of the age allowed with vigorous varieties, and the time is frequently reduced about one-half for weaker sorts. A careful grape grower will watch his plants. Any indication of a falling off in the amount, size, or quality of the fruit should be investigated, and with old vines it will often be found that the renewal of the youth of a vine will be followed by increased vigor and productiveness.

AN IDEAL DEPARTMENT OF AGRICULTURE AND INDUSTRIES.[1]

By E. Tisserand,

Councilor of State and Director of Agriculture of France.

[The report of the Parliamentary recess committee on the proposal to establish a department of agriculture and industries for Ireland, submitted to the chief secretary by the Rt. Hon. Horace Plunkett, M. P., chairman, on August 1, 1896, contains, among other valuable reports on State aid to agriculture and industry in various Continental countries, a very admirable and eloquent paper by M. E. Tisserand, councilor of state and director of agriculture of France, in which he discusses the organization of a model department of agriculture and industries. The report says:

"M. Tisserand is universally acknowledged to be one of the first authorities in Europe on agriculture and the administration of aid to agriculture by the State, and the French ministry of agriculture, of which he may be described as the permanent head, has been to a large degree shaped by his hand."

The paper, which was prepared at the request of the committee, contains "such advice as his unique experience would prompt him to offer on the constitution of a ministry of agriculture for Ireland, having special regard to the condition of that country."

Although prepared with special reference to Irish and Continental conditions, it is a paper of such breadth of view and general importance that it is reprinted here for the information of the American public from an advance copy received through the courtesy of the chairman of the committee.—C. W. D., Jr.]

NECESSITY FOR A DEPARTMENT OF AGRICULTURE.

A first point to be understood is that a ministry especially for agriculture has become in our day a necessity, an imperious need in all countries, whether they be States of old Europe or countries newly opened to civilization. This arises from the fact that everywhere nowadays agricultural and economical questions have assumed a capital importance and dominate all others. Everywhere man clings to the land; it is the earth that nourishes him, and, like the giant Antæus, he ever has need to touch it, to feel it beneath his feet, in order to renew his strength. It is a general sentiment that on the rational and scientific culture of the soil depend to-day the existence and power of nations.

Formerly, tradition, handed on from father to son, sufficed the husbandman for the advantageous utilization of the soil. The methods

[1] From Report of the Recess Committee (House of Commons) on the Establishment of a Department of Agriculture and Industries for Ireland. London, 1897.

of culture were simple; it called for no great effort of the mind to till well, to regulate the rotation of crops and the breeding of live stock. Everything went on in a restricted circle, and the son, working as his father before him had done, was able to live comfortably and bring up a numerous family. To-day the situation is no longer the same. In this extraordinary century, when everything has been profoundly modified by steam, when distances have disappeared, and the Australian with his wool, the Indian with his corn,[1] the American with his cattle and his dead meat, can reach the markets of Europe at less cost than it took the farmer of Yorkshire at the beginning of the century to get his produce to London, old methods and paternal traditions have become insufficient for the struggle which has to be carried on against foreign competition. It is no longer the struggle for life between man and man which is in question; it is the struggle for existence between industry and industry, between agriculture and agriculture, between country and country.

The struggle which agriculture has to sustain is all the more intense and severe because it has been less prepared for it. The formidable transformation brought about by the progress of railways, navigation, and the telegraph has had a greater effect on agriculture than on any other industry, because it has been surprised, so to speak, in the midst of the calm and quietude which it had been enjoying. It is no doubt a great boon to humanity that the products of the earth may overflow with an extreme facility from the regions in which they abound to the countries that need them; that every individual is assured his daily bread, and has no longer to fear the horrible famines which in other times periodically decimated the population; that, thanks to Australian wool and to the vast pasturages of the New World, the working man can obtain cheap clothing and cheap food to protect him against infirmity and give him health and strength. But if these are results to be thankful for from the humanitarian point of view, it is nevertheless true that they have had upon agriculture, through the general lowering of the prices of produce, an action which has placed it in a critical situation, and which has thrown the cultivators into confusion and brought discouragement and despair among the rural population. All thoughtful minds, the public powers, and Governments are occupied with these considerations. In all directions it is felt that the agriculture of Europe is like an old and leaking ship, tossed and buffeted about upon a sea of breakers, and that, to save it from foundering, it needs to be steered by abler hands and navigated by pilots who will join to a thorough practical training a profound and extensive scientific knowledge.

It is under the influence of these apprehensions and menaces and in the face of an abnormal and critical situation, in the hope of thus

[1] Reference is made here to the native of British India, and the word "corn" includes grain of every kind, with especial reference to wheat.

discovering and applying a remedy to an evil whose intensity goes on increasing, that there has come into being in almost every country the idea of creating a ministry of agriculture. This is a response to an imperious need. It is certainly not that the ambition of one more man may be satisfied, that we may have one minister the more, one politician the more, in the councils of Government and in the deliberative assemblies, that this idea has taken life. Its evolution has a higher reach and significance. "Ministry of agriculture" means an appeal for the help of all, a grouping and marshaling of the strength, the energies, and the wills of all, toward a determined and definite end—the raising up of agriculture. It means for the man who is placed at the head of such a ministry the obligation to study the needs of agriculture, to surround himself with the necessary assistants for the purpose, to cause the extent of the problem to be understood, to seek for practical solutions, to point them out to the Government, and to persuade Parliament to pass them into law.

The necessity for a ministry of agriculture being thus demonstrated, let us consider what the character, or, better, the spirit, of such an institution ought to be.

FUNDAMENTAL PRINCIPLES OF A DEPARTMENT OF AGRICULTURE.

There are those who let themselves believe that a ministry of agriculture ought to be a sort of Providence on which all might lean, and which could work miracles, to which it would only be necessary to apply to obtain remedies for all evils and boons for everybody. Others ask that it should centralize everything, absorb all the services, and take upon itself the functions of private individuals and voluntary associations.

Beware of these ideas and these fallacies. A ministry of agriculture ought to have for its essential and fundamental principle never to run counter to private or collective initiative. Far from that, all its efforts ought to tend to awaken the spirit of initiative and independence, and to stimulate and develop it among the agriculturists themselves. It ought to aid the weak, animate the indifferent, and stir up the courage of those who are tempted to let themselves be cowed by difficulties. The agriculturists must be made to understand that the improvement they desire depends as much on themselves as on the ministry, if not more so; that the latter must be powerless without their help; that they will receive succor from the State in proportion as they themselves put forth energy and labor; and that it is only by the united efforts of all concerned that progress can be brought about.

The ministry of agriculture, instead of substituting its own initiative for that of the cultivators or interfering with their independence

and that of their associations, ought to second free action on their part as much as possible.

To take some examples: A ministry of agriculture, whether by means of special laws or special encouragements, such as subsidies, subventions, medals, etc., should foster with all its power the combination of agriculturists—wherever such organizations do not already exist—in agricultural societies, consultative chambers, societies for insurance against mortality among stock and other calamities, societies for land improvement, cooperative societies (syndicats agricoles) for the purchase of manures, seeds, machines, etc., and for the sale of agricultural produce, credit societies, and institutions for mutual succor and assistance. It ought to do its utmost to encourage such societies, to live side by side with them, to come to their support whenever it is necessary, and to lend them the help of its agents.

It ought to inform the cultivators on all facts having a bearing on their industry, and to point out new methods and discoveries by which they may increase their crops, and protect them advantageously against parasites, noxious insects, microbes, etc.

METHODS OF CONTROL IN FRANCE.

The ministry of agriculture in France has always taken special care to respect the independence and working of the agricultural societies. It interferes only to aid them and to stimulate them to redouble their efforts, assisting them in proportion as they assist themselves. It increases the importance of the subventions and medals which it bestows in proportion to the exertions they put forth and the results they obtain. It is a struggle for emulation which the administration seeks to provoke, and it is by this means the best results are produced. It is these agricultural societies or clubs which themselves organize in the departments the encouragement to be given to the cultivators. They get up shows and give prizes for the diffusion of agricultural instruction, for the improvement of live stock, for the best seeds and manures and agricultural implements; they give prizes for good cultivation, and bestow rewards on meritorious farm servants. The State only takes charge of the great national or regional exhibitions to the number of six, and it is even a source of regret to the administration that these can not be organized by the great agricultural societies which have their headquarters in Paris. On every occasion on which it is possible, the ministry of agriculture appeals to the local societies and associations. To such an extent is this principle acted upon that, wishing recently to organize special shows for the principal breeds of horned cattle, sheep, and swine, the ministry delegated this task to various societies in the departments.

One thousand two hundred agricultural societies in France receive for distribution from the administration about 1,000,000 francs a year and several thousands of gold, silver, and bronze medals.

By this means the State accomplishes an enormous amount of good with a very little money. Indeed, it is impossible to exaggerate the amount of good will, of devotion, and disinterestedness which is available in the rural districts when an appeal is made to intelligent cultivators for a work to be accomplished. To give an instance, the materials for our great decennial agricultural statistics and for our annual statistics are collected for us in each locality by educated men who, without the least remuneration, devote themselves to difficult and sometimes toilsome researches in order to supply us with precious information on the rural economy of their communes. We give them some honorary recognition, a few medals, and they are satisfied.

ENCOURAGEMENT OF PRIVATE AGRICULTURAL SCHOOLS.

Even in the field of agricultural education private initiative is by no means to be despised, and may effect great things. If the ministry of agriculture has to occupy itself with creating, organizing, and keeping up the great public schools, the establishments for scientific research, the technical laboratories, and with the appointment and endowment of the professors charged with instructing the cultivators and carrying the light in all directions, there are cases in which the State may find a useful ally in private industry. Thus, in France we have found the means of making out of certain well-placed and well-managed farms excellent little practical schools. We give them, as the case may be, one or two experienced masters, and allow the manager of the farm a few hundred francs for the maintenance of four or five apprentices. For an expenditure of from 3,000 to 4,000 francs per establishment, we thus have some admirable little schools of dairying, cheese making, silkworm culture, bee keeping, etc.

COOPERATIVE AGRICULTURAL EXPERIMENTS.

Again, it is with the assistance of skillful farmers that the French administration establishes every year from 3,000 to 4,000 example plats (champs de demonstration), in which the agriculturists can see with their own eyes the trials of the best kinds of crops and the use of the most appropriate manures. It costs the ministry in the purchase of seeds, manures, and implements and the expense of superintendence some 150,000 to 170,000 francs a year to give to all our peasants a living illustration of the progress which may easily be realized by each of them. These example plats may be changed about so that their lessons may be brought within everybody's reach, even in the most remote corners of the country. The professors of agriculture explain in sight of each field the results obtained, and point out the improvements to make. Few institutions have brought about greater or more rapid progress among the class of small cultivators. I can not too strongly urge you to have recourse to them.

SECURING SCIENTIFIC ASSISTANTS.

Another task which a ministry of agriculture ought to set before itself is to attract to agriculture the most eminent scientists in chemistry, physics, physiology, entomology, mechanics, etc., so that they may be induced to occupy themselves with agricultural questions, and to direct their studies and their genius to the discovery of solutions affecting all branches of agriculture. The ministry must not be niggardly in its encouragements and subsidies to such men, for their discoveries will repay, with large interest, the expenditure which may have been incurred to enable them to carry on their researches. Moreover, there will by this means be prepared for agriculture an élite of men to direct it in the way of progress and of the application of science. It is by acting on these considerations that the ministry of agriculture in France has succeeded in effectuating considerable ameliorations in the condition of agriculture; it is owing to its subventions liberally distributed that Pasteur has been able to achieve his memorable work and his immortal discoveries, and that Boussingault, Berthelot, Schloesing, Aime, Girard, Blanchard, Chauveau, Georges, Ville, Prillieux, Nocard, Arloing, and so many other savants have contributed powerfully to agricultural progress.

It is by acting in accordance with these fundamental principles; it is—one can not too often repeat it—by respecting the liberty and the initiative of all, by stimulating and aiding, by good laws and wise regulations, the voluntary associations and institutions of the agricultural classes, that a ministry of agriculture will best succeed in fulfilling its mission. It ought to be, as it were, the flag around which will gather all the good will and all the energies which strive for the good of agriculture. It will sustain in this manner, among the rural population, that spirit of "self-help," that moral energy, which insures that a man, conscious of his duty to himself and to society, shall never abandon the struggle, shall feel his manhood and courage increasing with difficulties, and shall understand the necessity of joining his efforts to those of his fellow-citizens and the public powers in order to emerge a victor from the strife.

The spirit in which a ministry of agriculture ought to exercise its functions being thus defined, its field of action is none the less extensive.

THE SCOPE OF A DEPARTMENT OF AGRICULTURE.

If it be not called on to interfere directly with the work of private initiative, if it be its duty as well as its interest to respect scrupulously the independence and organization of the voluntary associations, it ought at the same time to watch carefully their working and the success of their efforts. It ought to listen to their wishes, to follow their discussions, to keep count of their needs, to prepare laws and rules calculated to foster their activity, and to distribute among

them, according to the importance of their work and of their own resources, the subventions, prizes, medals, etc., which are at its disposal. A ministry of agriculture ought to know everything, see everything, hear everything, so as to appreciate the needs of the country and to understand the reforms and improvements to be carried out.

FUNCTIONS OF AN IRISH DEPARTMENT OF AGRICULTURE.

In a country like Ireland, where agriculture plays the preponderating part, the ministry of agriculture ought, preferably, to include all or as many as possible of the branches which affect the agricultural interests. It ought to comprise within its jurisdiction the domains of the State—woods and forests, drainage and irrigation, water police, fisheries, restocking of rivers, pisciculture, etc. Legislation concerning property and the methods of holding it, etc., might also come within the scope of this ministry.

Agriculture and industry have intimate relations with each other. It has been well said that they are two sisters whose interests are identical. They live, in fact, side by side, depending one upon the other, having the same needs and aspirations, their schools organized and worked upon the same principles, individual, initiative, and voluntary associations acting in connection with them under similar conditions, the progress and prosperity of the one following the progress and prosperity of the other. Administrative action in their behalf ought, therefore, to proceed on similar lines. Thus, it seems to be of great importance for a country situated as Ireland is that the ministry of agriculture should embrace within its jurisdiction commerce and industry as well, so that, placed in the same hands and under a single management, there may be coordination without friction, and harmony in the efforts made by the State to advance their common interests.

In addition to its other functions, the administration of rural highways and lines of communication, whose development and efficient maintenance are of such high importance to agriculture, commerce, and industry alike, might be within the scope of such ministry.

Finally, the control of mines and quarries, having a relation to the usage of the soil, might also be logically attached to this department. This fusion exists in several countries, but it is not absolutely necessary, the point being one which clearly would depend upon the legal system and the existing organization of public works in each country.

DIVISIONS OF MINISTRY OF AGRICULTURE.

In our opinion, the ministry of agriculture for Ireland ought to comprise, at least in the main outlines, the following departments, or services:

(1) Agriculture; (2) commerce and industry; (3) rural highways, lines of communication, agricultural tramways, light railways, mines, and quarries; (4) forests, waterways, and State domains; (5) general accounts.

Each of these divisions, forming a distinct and homogeneous administration, would include services as follows:

AGRICULTURE.

(1) *Agricultural education.*—Schools of all grades, traveling professors, experiment stations, laboratories, agricultural charts, example plats, endowment of research and missions abroad, inspection of agricultural administration.

(2) *Encouragement to agriculture and legislation.*—Superior council, chambers of agriculture, agricultural associations and syndicates, societies for mutual help, agricultural shows, promotion of legislation, rural code, etc.

(3) *Agricultural hydraulics.*—Irrigation, drainage, reclamation, land-improvement loans, resources for the water supply of towns, contested claims, pisciculture, aquiculture.

(4) *Veterinary police administration.*

(5) *Statistics.*—Produce and market statistics, averages of prices, monthly information on the state of the crops, relief for losses incurred through calamities such as inundations, cattle plague, etc., bulletins and publications of the ministry, general statistics.

COMMERCE AND INDUSTRY.

(1) *Commerce.*—Chambers of commerce, tribunals of commerce, supervision of brokers, exchange agents, savings banks, insurance companies, tontines, encouragement to navigation, treaties of commerce, national and universal exhibitions.

(2) *Industry.*—Industrial and commercial legislation, inventions and patents, inspection of labor, industrial and commercial publications, statistics, information, etc.

(3) *Industrial and commercial education.*—Technical schools, art and trades schools, schools of mines, commercial museums, missions abroad, endowment of research, etc.

MINES, ROADS, WATERWAYS, ETC.

(1) *Mines and quarries.*—Legislation, working, concessions, supervision.

(2) *Roads and tramways.*—Concessions, construction, superintendence, extensions, legislation, water police, water courses, embankments, canals.

FORESTS, ETC.

Forestry staff and general service, forestry education, fellings and clearances, reafforesting, sale and disposition of timber, properties, administration, purchases, claims.

GENERAL ACCOUNTS.

Preparation of the general budget, examination of receipts and expenditures of the services, order pay department, disbursements and lodgments.

Constituted in this manner, the ministry of agriculture will form a compact whole, the management of which will not be beyond the strength of one man. The minister will be able easily to grasp and to dominate it in its entirety, and to impart to each of the great divisions which constitute it a fruitful and individual impulse.

If the ministry be restricted to narrower limits—to the agricultural division, for example, although that may be very vast in itself—the minister would not, in a country like Ireland, have an administration important enough for his position as a member of the Government. He would be reduced to being an employee, would give himself up to

details in order to have a sufficient occupation for his time and his activity, and would thus come to lose sight of the great general aims of his office. The separate departments of agriculture, commerce, and industry, wanting unity in their working and cohesion, would each go its own road, and their interests would be exposed to the great danger of friction, and even of clashing sometimes, to the great prejudice of the country. The ministry of agriculture would be thus partially paralyzed, and, in consequence, would be unable to render the country any appreciable service.

QUALIFICATIONS OF A MINISTER.

The minister, in the nature of things and according to the constitution of the country, must be a politician; and his fate is bound up with that of the cabinet of which he forms a part. He must therefore share its vicissitudes and his stay in office is limited to a period more or less indeterminate. This is a drawback, for it is through the continuity of effort that progress comes. Nevertheless, the injury done is less than one might suppose, for the advent of new men at the head of a government department, if it is to be regretted from some points of view, has the advantage of stimulating the services by bringing in new ideas. Each minister has his own conceptions, his own way of looking at things, schemes of his own for improvements and reforms, which oblige his colleagues to turn their attention to points hitherto neglected or left in the background, and almost always there result fresh effort and a sort of infusion of new life into the services. But if a minister may be changed for another without doing too much harm to the progress of business, there must be, on the other hand, great stability in the organization of the ministry. For if frequent changes were to be the rule among the officials and staff of the ministry, tradition would be lost and soon incoherence and hesitation would take the place of experience—fruit of long and patient labor at the same duties—and of indispensable order and unity of views.

QUALIFICATIONS OF HEADS OF DIVISIONS.

Unlike the minister, the men placed at the head of the different divisions of which we have spoken ought not to be politicians, subject to the vicissitudes of ministerial change. They ought to be professional men or experts, and their office ought to be of a permanent character. They ought to unite to a great experience of administration profound technical knowledge and an incontestable authority in the questions with which they have to deal. It is the director, or chief permanent official, whose duty it is to work with the minister, to enable him to understand departmental questions, to point out to him those to which he ought to direct his attention, and to indicate the reforms it is most important to proceed with and the progress it is most desirable to achieve.

It follows in the same way that the director, or permanent chief, of each division must have to second him, at the head of the various sections or bureaus of his department, intelligent and trained men, well versed in the practice of administration—men who will be able to devote themselves to details and conduct researches to which he would be unable to give his own time. Here again arises the necessity for great stability.

The number of officials and employees in each section, as well as their salaries, must be fixed by the minister in accordance with the credits voted by Parliament, but it must be the director who has the choosing of the staff placed under his orders. He must be their master, and he must be able, with the authority and approval of the minister, to reward those who have shown merit and zeal, and to punish those who do not properly discharge their duties. This, and my experience in the matter may be trusted, is an essential condition for the good working of the departments; only in this way will you save your offices from being clogged with encumbrances and good-for-nothings. Let the director himself be held absolutely responsible for the good working of his department, and let him be replaced if he proves inefficient.

In a ministry the work ought to be regulated and divided as in a manufactory. Each must have his part clearly fixed and defined, so that each official may know the task which he has to fulfill, and may perfect himself in the discharge of it.

CONSULTATIVE BODIES.

But it is not enough to have a well-organized ministry and well-constructed bureaus and departments. The minister must have beside him superior councils, consultative bodies, which, meeting two or three times a year, will put him in direct communication, so to speak, with the agricultural and industrial population, and keep him cognizant of their aspirations and their needs. These are veritable parliaments of agriculture, commerce, and industry, to whom the minister appeals for guidance on the important improvements and reforms to be carried out by means of laws, regulations, treaties of commerce, etc., and who give him their advice upon all questions of general interest to the ministry.

PERMANENT SCIENTIFIC COUNSELORS.

There ought to exist, side by side with these great councils, consultative committees for each branch of agriculture and industry, composed of the most renowned scientists and distinguished specialists. The rôle of these committees must be purely technical; they are business committees; politics has no part in them; they should serve as the permanent counselors of the administration.

COUNCILS OF AGRICULTURE, ARTS, AND MANUFACTURES.

In France we have in this connection a superior council of agriculture, a superior council of arts and manufactures, and a superior

council of commerce. These councils, according to their nature, are composed of agriculturists or manufacturers and merchants, and of men of science chosen from among the most distinguished of the country. Their members belong to all districts and to all branches of production. The superior councils, as they now exist, are not elective; their members are nominated by the President of the Republic and chosen from among members of the national legislature, agricultural and industrial societies, and chambers of commerce; scientists and high officials of the administration also belonging to them. But a bill has now been introduced into the Chamber by the minister of agriculture, providing that the superior council of agriculture shall not henceforth be nominated in its entirety by the Executive, but that the bulk of its members shall be elected by the agriculturists themselves and the peasant and other landed proprietors of the different departments. A small number of members chosen from the scientific and agricultural lights of the country will complete the council. The council will meet once or twice a year in Paris, and give its advice on the questions which will be submitted to it by the ministry.

I consider that the council thus constituted will have more authority and more independence, and will consequently render better service, than one the selection of whose members rests only with the minister. The superior councils of arts and manufactures and of commerce are to have a similar origin and organization.

PERMANENT TECHNICAL COMMITTEES.

As regards the permanent technical committees, it is the minister who chooses these. It is professional men, specialists, savants, and practical experts whom he needs for the current work, and to serve him as guides, and, so to speak, everyday counselors. It is for him to choose them as best he can, for the matter concerns him more than anyone else. Politics, let it be said once more, ought to be severely excluded from these considerations.

These committees, to do useful work, ought not to be too large. Twelve specialists, well chosen, having authority by their knowledge and experience, will work better and give better advice than twenty among whom some incompetent members may slip in. They sit at the ministry every week or fortnight or month, as the case may be, and their meetings last on an average two hours. They make reports on questions the examination of which is intrusted to them. These reports are then read and discussed, and their conclusions serve to guide the decisions taken by the ministry relative to each department. They are only called on, of course, to deliberate on matters which have some special importance, current business being dealt with by the directors. The members of these committees receive a fee of 15 francs for each sitting they attend. This is necessary to insure steady attendance at the sittings, and thus to obtain sustained work.

It will suffice to name some of these committees to enable their utility

and mechanism to be understood. Thus, at the ministry of agriculture in France we have—

(1) A special committee on phylloxera. This concerns itself with all questions relative to the methods of combating the phylloxera, and to the reconstitution of the wine-growing industry. It is composed of a dozen members.

(2) A committee of five members, whose task is to revise the demands for indemnities for vines destroyed through the invasion of the phylloxera, in execution of the law for the preservation of the wine-growing industry in Algeria.

(3) A technical committee, composed of twelve scientists, charged with the study and examination of the methods of destroying noxious insects and plants hurtful to agriculture.

(4) A committee on diseases of stock, composed of fourteen members, for the study of all questions relative to the sanitary or veterinary police in connection with infected animals, slaughtering, etc.

(5) A committee for the improvement of veterinary schools.

(6) A committee of inspectors-general of agriculture and of agricultural education meets once a week to examine questions relative to the establishment and organization of schools, to draw up the table of promotion for the teachers and staff, and to make propositions on their behalf for honorary rewards.

(7) A consultative committee on experiment stations and agricultural laboratories, charged with centralizing all business in this connection, and with studying the unification of methods of analysis of soils, manures, etc.

(8) A forestry committee for arranging for the felling of trees, clearing, replanting, etc.

(9) A consultative committee on agricultural hydraulics, which examines all business relating to irrigation, drainage, cleansing of rivers, etc.

(10) A superior council on studs, which has to deal with all improvements in the breeding of horses, with race meetings, the supply of remounts for the army, etc.

If you turn to the "Annuaire" of the ministry, you will see that these different committees are all composed of the most competent men available, chosen apart from any political consideration. They guide the administration in a reliable fashion on all questions which offer any difficulty, and they cover the responsibility of the minister.

For industry and commerce the permanent committees are equally numerous and varied.

Multiplication of these committees can not be too strongly urged. The minister will always obtain from them trustworthy advice and indispensable light for rightly seeing and judging and forming in full security the decisions which concern the department over which he presides. But, it can not be too often repeated, in composing them you must have no regard to pleasing one person or another, and must think only of bringing together the men of highest competence in their various branches, the men who are unquestioned and unquestionable authorities, so that their resolutions and advice may give you all the guaranties desirable. There are already quite enough causes of error without adding to them the absence of wise and able counselors.

Such are the bases on which I would advise you to found your ministry of agriculture. I do not doubt that under such conditions it will render the services which you expect from it, and you will be carrying out good administration and sound policy, to the great profit of the country.

APPENDIX.[1]

ORGANIZATION OF THE DEPARTMENT OF AGRICULTURE, DECEMBER 31, 1896.

[Location, The Mall, between Twelfth and Fourteenth streets.]

SECRETARY OF AGRICULTURE, J. Sterling Morton.

The Secretary of Agriculture is charged with the supervision of all public business relating to the agricultural industry. He appoints all the officers and employees of the Department, with the exception of the Assistant Secretary and the Chief of the Weather Bureau, who are appointed by the President, and directs the management of all the divisions, offices, and bureaus embraced in the Department. He exercises advisory supervision over the agricultural experiment stations deriving support from the National Treasury, and has control of the quarantine stations for imported cattle and of interstate quarantine rendered necessary by contagious cattle diseases.

ASSISTANT SECRETARY, Chas. W. Dabney, jr.

The Assistant Secretary performs such duties as may be prescribed by the Secretary. To his office have been assigned the control and direction of the scientific policy and operations of the following divisions and offices: The Divisions of Botany, Vegetable Physiology and Pathology, Agrostology, Pomology, Chemistry, Biological Survey, Entomology, and Agricultural Soils; the Office of Experiment Stations and the Office of Fiber Investigations, and the Department Museum. All questions relating to the scientific operations and policy of the above mentioned divisions and offices, but involving questions of administrative policy, while primarily matters for the consideration of the Assistant Secretary, are submitted to the Secretary for his approval before final action is taken.

CHIEF CLERK, D. MacCuaig.

The Chief Clerk has the general supervision of the clerks and employees; of the order of business, records, and correspondence of the Secretary's office; of all expenditures from appropriations for contingent expenses, stationery, etc.; of the enforcement of the general regulations of the Department, and of the buildings occupied by the Department of Agriculture.

SECTION OF FOREIGN MARKETS.—*Chief*, Frank H. Hitchcock.[2]

The Section of Foreign Markets makes investigations and disseminates information "concerning the feasibility of extending the demands of foreign markets for the agricultural products of the United States."

LIBRARIAN, W. P. Cutter.

BUREAUS AND DIVISIONS.

WEATHER BUREAU (corner Twenty-fourth and M streets NW.).—*Chief*, Willis L. Moore; *assigned as Assistant Chief*, Major H. H. C. Dunwoody, U. S. A.; *Chief Clerk*, James R. Cook; *Professors of Meteorology*, Cleveland Abbe, F. H. Bigelow, Henry A. Hazen, Charles F. Marvin, Edward B. Garriott.

The Weather Bureau has charge of the forecasting of weather; the issue of storm warnings; the display of weather and flood signals for the benefit of

[1] For subject-matter of Appendix, see under Contents, page 5.
[2] Appointed January 9, 1897.

agriculture, commerce, and navigation; the gauging and reporting of rivers; the maintenance and operation of seacoast telegraph lines, and the collection and transmission of marine intelligence for the benefit of commerce and navigation; the reporting of temperature and rainfall conditions for the cotton, rice, sugar, and other interests; the display of frost and cold-wave signals; the distribution of meteorological information in the interests of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the United States, or as are essential for the proper execution of the foregoing duties.

Bureau of Animal Industry.—*Chief*, D. E. Salmon; *Assistant Chief*, G. M. Brumbaugh; *Chief Clerk*, S. R. Burch; *Chief of Inspection Division*, A. D. Melvin; *Chief of Miscellaneous Division*, A. M. Farrington; *Chief of Pathological Division*, Victor A. Nörgaard; *Chief of Biochemic Division*, E. A. de Schweinitz; *Chief of Dairy Division*, Henry E. Alvord; *Zoologist*, Ch. Wardell Stiles; *In charge of Experiment Station*, E. C. Schroeder.

The Bureau of Animal Industry makes investigations as to the existence of contagious pleuropneumonia and other dangerous communicable diseases of live stock, superintends the measures for their extirpation, makes original investigations as to the nature and prevention of such diseases, and reports on the condition and means of improving the animal industries of the country. It also has charge of the inspection of import and export animals, of the inspection of vessels for the transportation of export cattle, and of the quarantine stations for imported neat cattle; supervises the interstate movement of cattle, and inspects live stock and their products slaughtered for food consumption.

Division of Statistics.—*Statistician*, Henry A. Robinson; *Assistant Statistician*, Henry Farquhar.

The Division of Statistics collects information as to the condition, prospects, and harvests of the principal crops, and of the numbers and status of farm animals, through a corps of county correspondents and the aid of a supplementary organization under the direction of State agents, and obtains similar information from European countries monthly through the deputy consul-general at London, assisted by consular, agricultural, and commercial authorities. It records, tabulates, and coordinates statistics of agricultural productions, distribution, and consumption, the authorized data of Governments, institutes, societies, boards of trade, and individual experts, and issues a monthly crop report and occasional bulletins for the information of producers and consumers, and for their protection against combination and extortion in the handling of the products of agriculture.

Office of Experiment Stations.—*Director*, A. C. True; *Assistant Director*, E. W. Allen.

The Office of Experiment Stations represents the Department in its relations to the experiment stations which are now in operation in all the States and Territories. It seeks to promote the interests of agricultural education and investigation throughout the United States. It collects and disseminates general information regarding the colleges and stations, and publishes accounts of agricultural investigations at home and abroad. It also indicates lines of inquiry, aids in the conduct of cooperative experiments, reports upon the expenditures and work of the stations, and in general furnishes them with such advice and assistance as will best promote the purposes for which they were established. It is also charged with investigations on the nutritive value and economy of human foods.

Division of Chemistry.—*Chief Chemist*, Harvey W. Wiley; *First Assistant Chemist*, ———.

The Division of Chemistry makes investigations of the methods proposed for the analyses of soils, fertilizers, and agricultural products, and such analyses as pertain in general to the interests of agriculture. It can not undertake the analyses of samples of the above articles of a miscellaneous nature, but application for such analyses should be made to the directors of the agricultural experiment stations of the different States. The division does not make assays of ores nor analyses of minerals except when related to general agricultural interests, nor analyses of water.

Division of Entomology.—*Entomologist*, L. O. Howard; *First Assistant Entomologist*, C. L. Marlatt.

The Division of Entomology obtains and disseminates information regarding insects injurious to vegetation; investigates insects sent to the division in order

to give appropriate remedies; conducts investigations of this character in different parts of the country, and mounts and arranges specimens for illustrative and museum purposes.

DIVISION OF BIOLOGICAL SURVEY.—*Chief*, C. Hart Merriam; *Assistant Chief*, T. S. Palmer.

The Division of Biological Survey studies the geographic distribution of animals and plants, and maps the natural life zones of the country; it also investigates the economic relations of birds and mammals, and recommends measures for the preservation of beneficial and the destruction of injurious species.

DIVISION OF FORESTRY.—*Chief*, B. E. Fernow; *Assistant Chief*, Charles A. Keffer.

The Division of Forestry is occupied with experiments, investigations, and reports dealing with the subject of forestry, and with the dissemination of information upon forestry matters.

DIVISION OF BOTANY.—*Botanist*, Frederick V. Coville; *First Assistant Botanist*, G. H. Hicks.

The Division of Botany investigates botanical agricultural problems, including the purity and value of agricultural seeds; methods of controlling the spread of weeds or preventing their introduction into this country; the dangers, effects, and antidotes for poisonous plants; the native plant resources of the country, and other subjects of economic botany.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.—*Chief*, B. T. Galloway; *First Assistant Chief*, Albert F. Woods.

The Division of Vegetable Physiology and Pathology has for its object a study of the normal and abnormal life processes of plants. It seeks by investigations in the field and experiments in the laboratory to determine the causes of disease and the best means of preventing the same. It studies plant physiology in its bearing on pathology.

DIVISION OF AGROSTOLOGY.—*Chief*, F. Lamson-Scribner; *First Assistant Chief*, Jared G. Smith.

The Division of Agrostology is charged with the investigation of the natural history, geographical distribution, and uses of grasses and forage plants, their adaptation to special soils and climates, the introduction of promising native and foreign kinds into cultivation, and the preparation of publications and correspondence relative to these plants.

DIVISION OF POMOLOGY.—*Pomologist*, Samuel B. Heiges; *Assistant Pomologist*, W. A. Taylor.

The Division of Pomology collects and distributes information in regard to the fruit interests of the United States; investigates the habits and peculiar qualities of fruits, their adaptability to various soils and climates, and conditions of culture, and introduces new and untried fruits from foreign countries.

DIVISION OF AGRICULTURAL SOILS.—*Chief*, Milton Whitney.

The Division of Agricultural Soils has for its object the investigation of the texture and other physical properties of soils and their relation to crop production.

OFFICE OF FIBER INVESTIGATIONS.—*Special Agent in Charge*, Chas. Richards Dodge.

The Office of Fiber Investigations collects and disseminates information regarding the cultivation of textile plants, directs experiments in the culture of new and hitherto unused plants, and investigates the merits of new machines and processes for preparing them for manufacture.

OFFICE OF PUBLIC ROAD INQUIRIES.—*Director*, Roy Stone.

The Office of Public Road Inquiries collects information concerning the systems of road management throughout the United States, conducts investigations regarding the best method of road making, and prepares publications on this subject.

GARDENS AND GROUNDS.—*Horticulturist and Superintendent of Gardens and Grounds*, William Saunders.

The Division of Gardens and Grounds is charged with the care and ornamentation of the park surrounding the Department buildings, and with the duties connected with the conservatories and gardens for testing and propagating economic plants.

DIVISION OF PUBLICATIONS.—*Chief*, Geo. Wm. Hill; *Assistant Chief*, Joseph A. Arnold; *Superintendent of Document and Folding Room*, George F. Thompson.

The Division of Publications exercises general supervision of the Department printing and illustrations, and has charge of the distribution of all Department publications with the exception of those turned over by law to the Superintendent of Documents for sale at the price affixed by him; it issues, in the form of press notices, official information of interest to agriculturists, and distributes to agricultural publications and writers synopses of Department publications.

DIVISION OF ACCOUNTS AND DISBURSEMENTS.—*Chief*, Frank L. Evans; *Assistant Disbursing Officer* (in charge of Weather Bureau disbursements), A. Zappone; *Cashier*, Everett D. Yerby.

The Division of Accounts and Disbursements is charged with the adjustment of all claims against the Department; decides questions involving the expenditure of public funds; prepares contracts for annual supplies, leases, and agreements; issues requisitions for the purchase of supplies, requests for passenger and freight transportations, and attends to all business relating to the financial interests of the Department, including payments of every description.

THE PUBLIC DOMAIN.

Since the original publication of the report of the Secretary of Agriculture (pages 9–54 of this volume) the following additional information relative to the disposition of the public domain referred to therein has become available:[1]

"The homestead act was passed May 20, 1862, since which time 162,892,132 acres have been entered by homestead settlers. Of this amount, 102,902,409 acres have been patented or will be patented when the conditions of the law have been complied with. Of the remainder, it is estimated 42,000,000 acres represent entries which have been canceled, and 17,989,723 acres commuted to cash and accounted for under that head.

"It is estimated that 335,691,752 acres have been disposed of by preemption, cash sales, scrip locations of all kinds, military bounty-land warrants, town-site, desert-land, timber-culture, timber and stone entries, Indian allotments, and donations to settlers.

"The total number of mineral entries made under laws providing therefor is 29,820 (including coal entries), of which 1,149 have been canceled, the remaining entries embracing an estimated area of 573,420 acres.

"There have been patented to railroads and wagon roads since September 20, 1850, when the first grant was made, * * * 85,729,751 acres. * * *

"In addition to the lands patented, there are yet due to railroads and wagon roads under their grants about 114,736,639 acres, of which not more than 60 per cent, or about 70,000,000 acres, are available for patenting under the conditions of the grants, as the remainder of the granted and indemnity lands have been taken by actual settlers, or are within the 6-mile limits of mineral lands.

"The total grants of lands to the various States and Territories up to March 12, 1896, aggregated 181,868,630 acres, in addition to agricultural college scrip for 7,830,000 acres and 22,000 acres granted to the State of Kentucky for a deaf and dumb asylum, both heretofore taken into account. All the lands granted to the States and Territories have not, however, been segregated from the public domain, the actual amount segregated being estimated at 156,232,615 acres, of which 66,423,297 acres were for the support of the common schools, 5,623,120 acres (in addition to scrip) for the benefit of agricultural and mechanical colleges and universities, and the remainder (of which 80,620,000 acres are estimated as swamp land) was given for public buildings, charitable, penal, and reformatory institutions, and for internal improvements.

* * * * * * *

"In addition to the foregoing disposition of the public domain, it is estimated that 78,500,000 acres have been segregared by private grants from Congress, and by claims which had their origin under concessions from a foreign Government before the acquisition by the United States of the territory in which they are located.

"The total of all lands segregated under the above heads [together with the existing Indian, military, and forest reservations and the National parks] aggregates 946,219,160 acres.

* * * * * * *

"In the past thirteen years * * * the Government has, by patents to States,

[1] See Annual Report of the Secretary of the Interior for the fiscal year ending June 30, 1896.

railroads, homestead and other settlers, and by sales, disposed of about 326,000,000 acres of the public domain. * * * Moreover, it is reasonable to conclude that a very considerable portion of the public domain remaining undisposed of is undesirable, because not susceptible of cultivation and not valuable by reason of timber growth or mineral deposits."

STATISTICS OF THE PRINCIPAL CROPS AND FARM ANIMALS.

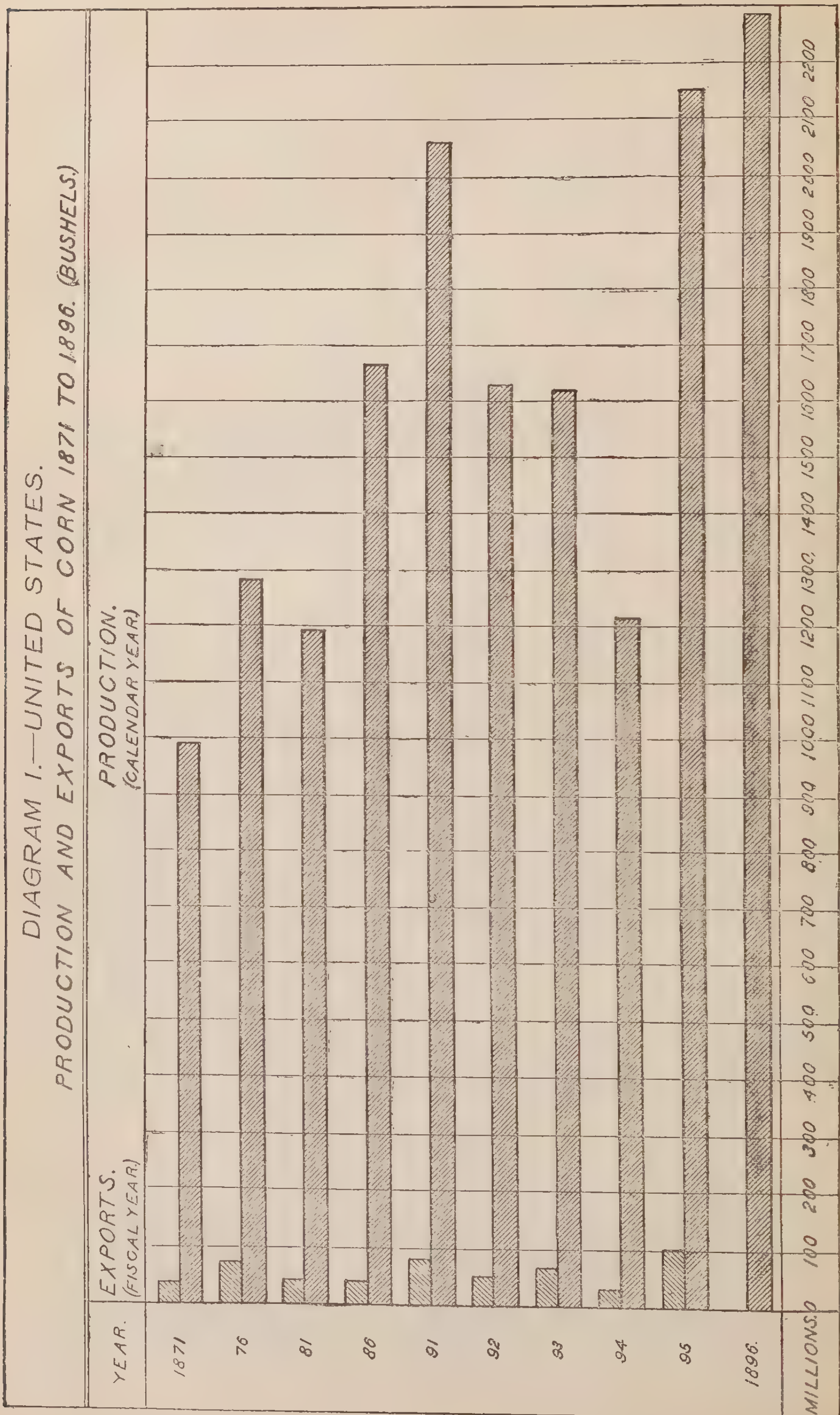
Acreage, production, and value of corn and wheat in 1896.

State or Territory.	Corn.			Wheat.		
	Acres.	Bushels.	Value.	Acres.	Bushels.	Value.
Maine	14,780	546,860	$257,024	7,770	170,940	$143,590
New Hampshire	27,660	1,161,720	522,774	2,447	51,387	51,387
Vermont	48,642	1,994,322	757,842	8,407	205,972	191,554
Massachusetts	42,920	1,845,560	848,958			
Rhode Island	8,848	300,832	147,408			
Connecticut	46,658	1,773,004	744,662			
New York	526,257	17,892,738	6,799,240	396,873	6,319,968	5,587,972
New Jersey	282,586	9,325,333	3,357,122	101,651	1,465,260	1,384,181
Pennsylvania	1,311,875	52,475,000	17,316,750	1,266,949	17,787,286	14,721,947
Delaware	224,258	4,933,676	1,233,419	97,712	1,758,816	1,530,170
Maryland	623,004	19,936,128	6,379,561	463,457	7,878,769	6,933,317
Virginia	1,770,604	38,067,986	12,181,756	615,582	5,724,913	4,579,930
North Carolina	2,458,679	29,504,148	10,916,535	633,140	4,621,922	3,836,195
South Carolina	1,753,486	15,781,374	7,259,432	149,868	957,902	852,583
Georgia	2,984,514	32,829,654	14,116,751	212,484	1,699,872	1,512,886
Florida	486,494	4,859,949	2,576,293			
Alabama	2,595,606	32,445,075	14,600,284	49,273	394,184	335,056
Mississippi	2,072,103	27,973,390	12,308,292	4,462	37,927	31,100
Louisiana	1,197,310	15,565,030	7,004,264			
Texas	3,392,486	32,228,617	13,213,733	387,112	4,529,210	3,396,908
Arkansas	2,201,767	29,723,854	10,997,826	157,590	1,269,720	895,111
Tennessee	3,125,892	71,893,446	20,130,165	779,819	6,628,462	4,905,062
West Virginia	722,972	21,689,160	7,374,314	393,836	4,056,511	3,164,079
Kentucky	2,899,441	80,932,348	29,233,687	801,938	6,976,851	5,302,414
Ohio	3,016,877	123,691,957	25,975,311	2,422,224	21,800,016	17,004,012
Michigan	1,053,755	40,041,930	9,610,663	1,228,117	15,719,898	13,204,714
Indiana	3,813,379	133,468,265	25,358,970	2,294,160	20,647,440	16,517,952
Illinois	7,026,488	284,572,764	51,223,098	1,950,214	28,668,146	21,214,428
Wisconsin	1,051,083	38,890,071	8,555,816	669,094	8,898,950	6,229,265
Minnesota	1,139,109	31,416,974	6,541,925	3,281,624	46,599,061	31,692,361
Iowa	8,249,219	321,719,541	45,040,736	717,072	11,473,152	7,113,354
Missouri	6,516,957	176,768,619	35,353,730	1,418,331	16,594,473	11,618,131
Kansas	8,847,663	247,731,004	44,592,121	2,905,137	30,791,452	19,400,505
Nebraska	7,962,657	296,590,638	58,817,953	1,385,043	19,390,602	11,246,519
South Dakota	1,197,575	31,136,550	5,604,651	2,462,898	27,583,450	17,101,739
North Dakota	27,844	974,540	243,635	2,529,534	29,848,501	19,103,041
Montana	1,331	34,606	20,764	45,443	1,204,240	794,798
Wyoming	2,483	62,075	48,418	9,148	224,126	138,958
Colorado	178,303	2,852,928	1,027,054	159,839	2,797,182	1,706,281
New Mexico	21,260	588,160	213,188	38,957	818,097	539,944
Arizona				14,500	333,500	266,800
Utah	8,650	216,250	110,288	105,802	2,803,753	1,906,552
Nevada				6,001	180,030	124,221
Idaho				98,127	2,404,112	1,562,673
Washington	6,818	95,452	54,408	461,344	8,558,192	6,185,062
Oregon	13,529	297,638	166,677	602,773	10,217,141	7,377,942
California	59,529	2,202,573	1,167,364	3,058,819	45,097,195	37,439,672
Oklahoma				200,135	2,601,755	1,769,193
Total	81,027,156	2,283,875,165	491,006,967	34,618,646	427,684,346	310,602,539

Production and exports of corn for the years 1894 to 1896.

Year.	Total area of crop.	Total production.	Total value of crop.	Value per bushel.	Yield per acre.	Value per acre.	Exports for fiscal year.	
	Acres.	*Bushels.*	*Dollars.*	*Cents.*	*Bushels.*	*Dolls.*	*Bushels.*	*Per ct.*
1894	62,582,269	1,212,770,052	554,719,162	45.7	19.4	8.86	28,585,405	2.4
1895	82,075,830	2,151,138,580	544,985,534	25.3	26.2	6.64	101,100,375	4.7
1896	81,027,156	2,283,875,165	491,006,967	21.5	28.2	6.06		

DIAGRAM I.—UNITED STATES.
PRODUCTION AND EXPORTS OF CORN 1871 TO 1896. (BUSHELS.)



[NOTE.—The exports are for the twelve months *beginning* July 1 of the year set opposite to them.]

Production and exports of wheat for the years 1894 to 1896.

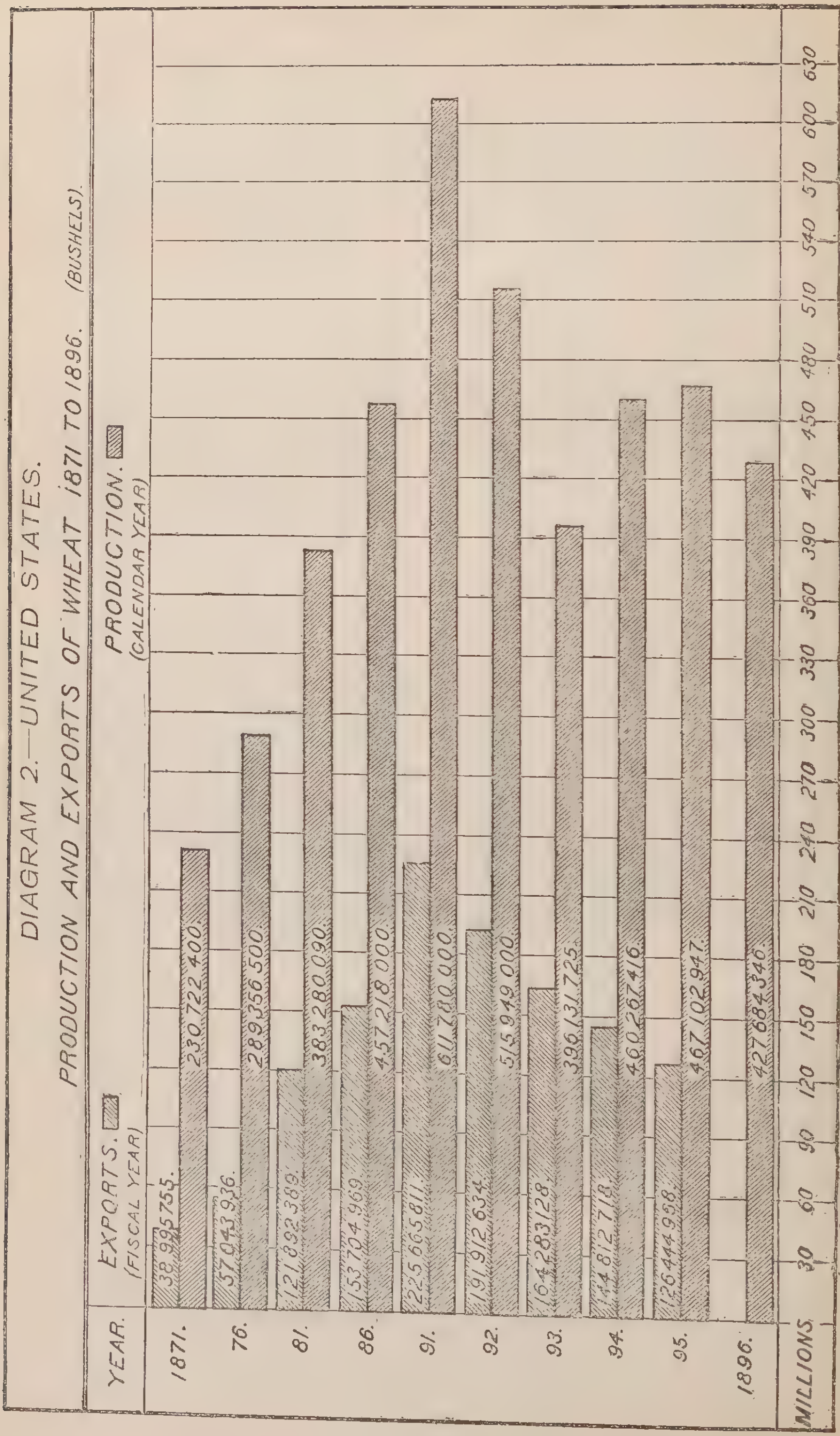
Year.	Total area of crop.	Total production.	Total value of crop.	Value per bushel.	Yield per acre.	Value per acre.	Exports for fiscal year.	
	Acres.	*Bushels.*	*Dollars.*	*Cents.*	*Bushels.*	*Dolls.*	*Bushels.*	*Per ct.*
1894	34,882,436	460,267,416	225,902,025	49.1	13.2	6.48	144,812,718	31.5
1895	34,047,332	467,102,947	237,938,998	50.9	13.7	6.99	126,443,968	27.1
1896	34,618,646	427,684,346	310,602,539	72.6	12.4	8.97	----------	------

Disposition of the corn crop of 1896.

State or Territory.	Crop of 1896.	Stock on hand March 1, 1897.		Consumed in county where grown.		Shipped out of county where grown.		Merchantable.	
	Bushels.	*Bushels.*	*P.ct.*	*Bushels.*	*P.ct.*	*Bushels.*	*P.ct.*	*Bushels.*	*P.ct.*
Maine	546,860	164,058	30	541,391	99	5,469	1	426,551	78
New Hampshire	1,161,720	406,602	35	1,161,720	100	----------	-----	1,033,931	89
Vermont	1,994,322	817,672	41	1,994,322	100	----------	-----	1,735,060	87
Massachusetts	1,845,560	627,490	34	1,845,560	100	----------	-----	1,605,637	87
Rhode Island	300,832	141,391	47	285,790	95	15,042	5	264,732	88
Connecticut	1,773,004	656,011	37	1,737,544	98	35,460	2	1,489,323	84
New York	17,892,738	8,051,732	45	17,355,956	97	536,782	3	14,493,118	81
New Jersey	9,325,338	4,103,149	44	8,392,804	90	932,534	10	8,299,551	89
Pennsylvania	52,475,000	23,613,750	45	46,178,000	88	6,297,000	12	45,128,500	86
Delaware	4,933,676	2,466,838	50	3,206,889	65	1,726,787	35	4,341,635	88
Maryland	19,936,128	9,170,619	46	13,157,844	66	6,778,284	34	17,344,431	87
Virginia	38,067,986	17,891,953	47	31,977,108	84	6,090,878	16	31,977,108	84
North Carolina	29,504,148	13,276,867	45	27,733,899	94	1,770,249	6	23,898,360	81
South Carolina	15,781,374	8,048,501	51	15,465,747	98	315,627	2	14,045,423	89
Georgia	32,829,654	16,414,827	50	31,516,468	96	1,313,186	4	27,905,206	85
Florida	4,860,940	1,944,376	40	4,569,284	94	291,656	6	3,791,533	78
Alabama	32,445,075	14,924,734	46	30,822,821	95	1,622,254	5	26,604,962	82
Mississippi	27,973,390	12,308,292	44	27,134,188	97	839,202	3	23,497,648	84
Louisiana	15,565,030	4,980,810	32	15,253,729	98	311,301	2	11,673,772	75
Texas	32,228,617	6,123,437	19	31,261,758	97	966,859	3	18,048,026	56
Arkansas	29,723,854	9,214,395	31	29,426,615	99	297,239	1	19,617,744	66
Tennessee	71,893,446	30,195,247	42	60,390,495	84	11,502,951	16	61,109,429	85
West Virginia	21,689,160	9,109,447	42	19,520,244	90	2,168,916	10	18,002,003	83
Kentucky	80,932,348	36,419,557	45	72,839,113	90	8,093,235	10	67,983,172	84
Ohio	123,691,957	61,845,978	50	87,821,289	71	35,870,668	29	110,085,842	89
Michigan	40,041,930	18,819,707	47	35,236,898	88	4,805,032	12	34,436,060	86
Indiana	133,468,265	69,403,498	52	90,758,420	68	42,709,845	32	122,790,804	92
Illinois	284,572,764	156,515,020	55	159,360,748	56	125,212,016	44	261,806,943	92
Wisconsin	38,890,071	17,111,631	44	36,167,766	93	2,722,305	7	31,500,958	81
Minnesota	34,446,974	15,501,138	45	32,035,686	93	2,411,288	7	26,524,170	77
Iowa	321,719,541	193,031,725	60	228,420,874	71	93,298,667	29	231,638,070	72
Missouri	176,768,649	83,081,265	47	152,021,038	86	24,747,611	14	148,485,665	84
Kansas	247,734,004	121,389,662	49	165,981,783	67	81,752,221	33	227,915,284	92
Nebraska	298,599,638	176,173,786	59	146,313,823	49	152,285,815	51	265,753,678	89
South Dakota	31,136,950	18,682,170	60	26,155,038	84	4,981,912	16	25,220,930	81
North Dakota	974,540	243,635	25	964,795	99	9,745	1	682,178	70
Montana	34,606	6,921	20	34,606	100	----------	-----	27,685	80
Wyoming	62,075	31,038	50	57,730	93	4,345	7	40,349	65
Colorado	2,852,928	713,232	25	2,767,340	97	85,588	3	2,196,755	77
New Mexico	388,160	124,211	32	364,870	94	23,290	6	333,818	86
Arizona	----------	----------	30	----------	90	----------	10	----------	87
Utah	216,250	54,062	25	207,600	96	8,650	4	157,862	73
Nevada	----------	----------	30	----------	85	----------	15	----------	85
Idaho	----------	----------	22	----------	100	----------	0	----------	82
Washington	95,452	19,090	20	87,816	92	7,636	8	81,134	85
Oregon	297,638	35,717	12	285,732	96	11,906	4	229,181	77
California	2,202,573	550,643	25	1,806,110	82	396,463	18	1,982,316	90
Oklahoma	----------	----------	29	----------	84	----------	16	----------	78
Total	2,283,875,165	1,164,405,884	51	1,660,619,251	72.7	623,255,914	27.3	1,936,206,537	84.8

DIAGRAM 2.—UNITED STATES.

PRODUCTION AND EXPORTS OF WHEAT 1871 TO 1896. (BUSHELS).



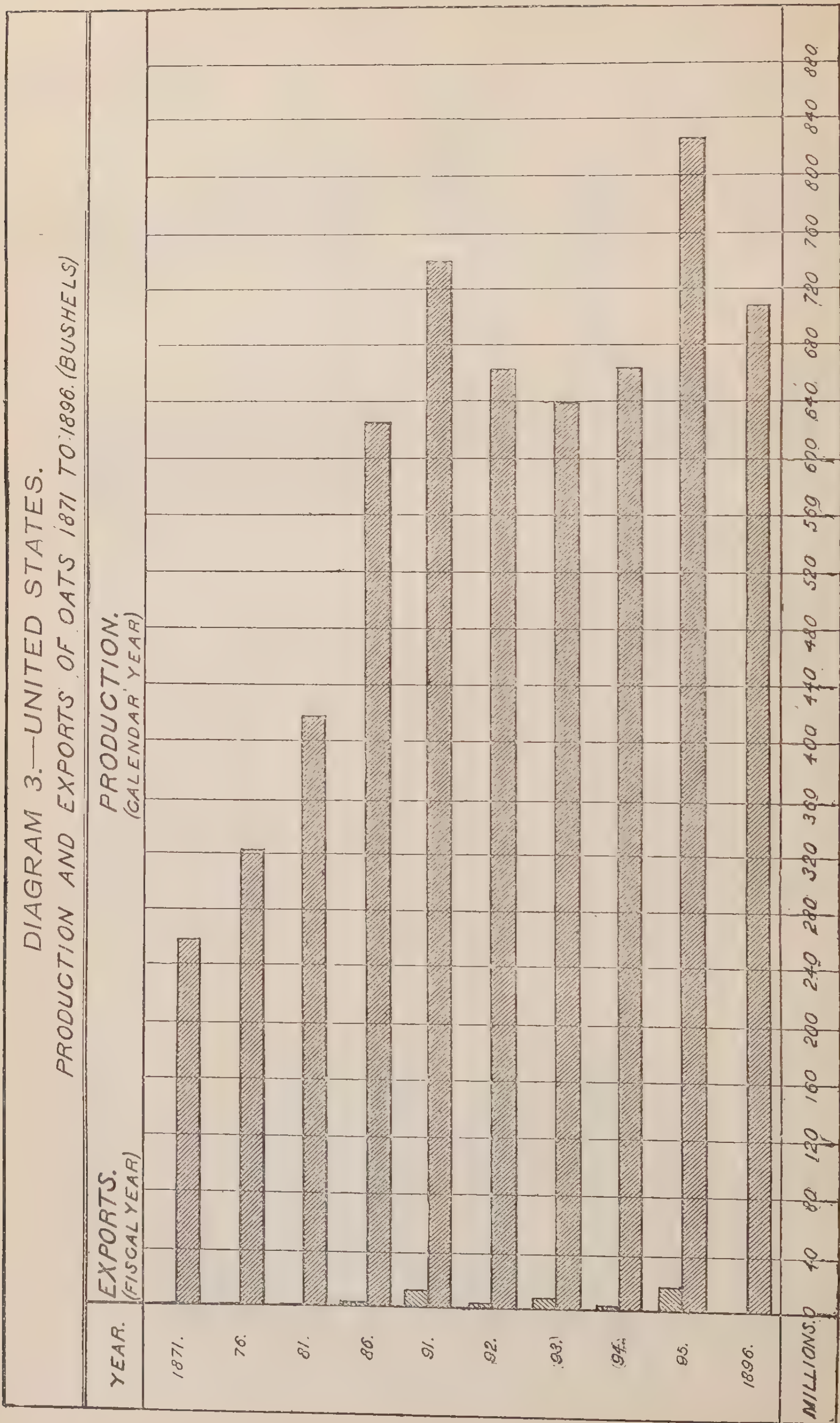
[NOTE.—The exports are for the twelve months *beginning* July 1 of the year set opposite to them.]

Disposition of the wheat crop of 1896.

State or Territory.	Crop of 1896.	Stock on hand March 1, 1897.		Consumed in county where grown.		Shipped out of county where grown.		Weight per bushel.
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Pounds.*
Maine	170,940	73,504	43	170,940	100			58
New Hampshire	51,387	15,416	30	51,387	100			56
Vermont	205,972	74,150	36	205,972	100			60
New York	6,349,968	2,222,489	35	4,000,480	63	2,349,488	37	58
New Jersey	1,555,260	404,368	26	1,353,076	87	202,184	13	60
Pennsylvania	17,737,286	5,321,186	30	13,302,964	75	4,434,322	25	58
Delaware	1,758,816	386,940	22	756,291	43	1,002,525	57	59
Maryland	7,878,769	1,575,754	20	3,151,508	40	4,727,261	60	58
Virginia	5,724,913	1,202,232	21	3,434,948	60	2,289,965	40	58
North Carolina	4,621,922	1,155,480	25	4,483,264	97	138,658	3	58
South Carolina	957,902	143,685	15	957,902	100			59
Georgia	1,699,872	305,977	18	1,648,876	97	50,996	3	58
Alabama	394,184	55,186	14	382,358	97	11,826	3	56
Mississippi	37,927	7,965	21	37,927	100			57
Texas	4,529,210	543,505	12	4,076,289	90	452,921	10	56
Arkansas	1,260,720	277,358	22	1,147,255	91	113,465	9	57
Tennessee	6,628,462	1,325,692	20	4,308,500	65	2,319,962	35	57
West Virginia	4,056,511	1,095,258	27	3,042,383	75	1,014,128	25	58
Kentucky	6,976,861	1,046,529	15	4,395,422	63	2,581,439	37	56
Ohio	21,800,016	5,014,004	23	14,606,011	67	7,194,005	33	54
Michigan	15,719,898	3,772,776	24	6,916,755	44	8,803,143	56	58
Indiana	20,647,440	3,510,065	17	11,562,566	56	9,084,874	44	56
Illinois	28,668,146	4,586,903	16	14,334,073	50	14,334,073	50	56
Wisconsin	8,898,950	3,025,643	34	7,208,150	81	1,690,800	19	55
Minnesota	46,599,061	12,115,756	26	15,843,681	34	30,755,380	66	56
Iowa	11,473,152	3,556,677	31	7,228,086	63	4,245,066	37	57
Missouri	16,594,473	2,821,060	17	9,126,960	55	7,467,513	45	56
Kansas	30,794,452	4,927,112	16	15,397,226	50	15,397,226	50	56
Nebraska	19,390,602	5,429,369	28	9,695,301	50	9,695,301	50	56
South Dakota	27,583,450	7,447,532	27	8,275,035	30	19,308,415	70	57
North Dakota	29,848,501	5,372,730	18	6,566,670	22	23,281,831	78	57
Montana	1,204,240	240,848	20	1,047,689	87	156,551	13	56
Wyoming	224,126	71,720	32	201,713	90	22,413	10	62
Colorado	2,797,182	559,436	20	1,762,225	63	1,034,957	37	59
New Mexico	818,097	171,800	21	719,925	88	98,172	12	58
Arizona	333,500	66,700	20	296,815	89	36,685	11	60
Utah	2,803,753	841,126	30	1,514,027	54	1,289,726	46	60
Nevada	180,030	28,805	16	149,425	83	30,605	17	58
Idaho	2,404,112	528,905	22	961,645	40	1,442,467	60	59
Washington	8,358,192	919,401	11	2,507,458	30	5,850,734	70	60
Oregon	10,247,141	1,537,071	15	3,688,971	36	6,558,170	64	59
California	45,097,195	4,058,748	9	14,431,102	32	30,666,093	68	60
Oklahoma	2,601,755	312,211	12	1,509,018	58	1,092,737	42	59
Total	427,684,346	88,149,072	20.6	206,458,269	48.3	221,226,077	51.7	57.1

Quantities of wheat and wheat flour exported from the United States to the leading countries of destination during the five years ending June 30, 1896.

Country to which exported.	Year ending June 30—					Annual average, 1892–1896.	
	1892.	1893.	1894.	1895.	1896.		
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*	*P. ct.*
Belgium	20,491,228	9,674,903	7,850,504	5,919,209	3,436,189	9,474,406	5.5
Denmark	1,926,351	1,813,373	1,151,141	802,676	629,661	1,264,640	.7
France	43,086,297	7,502,565	8,709,934	1,601,750	127,472	12,205,604	7.2
Germany	7,880,172	4,080,062	3,048,359	3,681,855	1,751,212	4,088,332	2.4
Netherlands	11,051,313	12,847,732	11,992,395	7,584,113	3,755,666	9,446,244	5.5
Portugal	3,161,013	5,008,230	5,757,623	2,692,078	3,098,101	3,943,409	2.3
Sweden and Norway	1,389,337	1,047,132	747,563	713,720	464,062	872,363	.5
United Kingdom	110,511,555	119,141,504	95,810,986	94,087,087	80,598,639	100,029,954	58.6
Canada	6,986,654	7,772,419	6,286,943	7,714,739	7,149,875	7,182,126	4.2
Central America	1,068,754	1,019,454	1,163,340	1,309,045	1,198,301	1,151,779	.7
Mexico	155,770	249,451	238,780	242,230	211,881	218,022	.1
British West Indies	2,143,498	2,303,282	2,476,809	2,344,948	2,578,714	2,369,450	1.4
Cuba	1,647,886	2,775,053	2,980,116	1,709,376	795,357	1,981,548	1.2
Brazil	4,298,084	3,830,604	4,143,973	3,489,475	3,921,659	3,934,759	2.3
British Guiana	709,376	818,370	984,812	878,954	751,653	823,633	.5
Venezuela	883,607	955,174	974,447	921,600	986,687	944,303	.6
Hongkong	2,059,605	2,475,594	2,626,236	3,554,043	3,718,031	2,886,702	1.7
Other countries	6,214,362	8,606,733	7,359,168	5,565,822	11,270,808	7,801,378	4.6
Total	225,665,812	191,912,635	164,283,129	144,812,718	126,443,968	170,623,652	100.0



[NOTE.—The exports are for the twelve months *beginning* July 1 of the year set opposite to them.]

Disposition of the oat crop of 1896.

State or Territory.	Crop of 1896.	Stock on hand March 1, 1897.		Consumed in county where grown.		Shipped out of county where grown.		Weight per bushel.
	Bushels.	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Bushels.*	*P. ct.*	*Pounds*
Maine	5,869,880	2,758,844	47	5,517,687	94	352,193	6	32
New Hampshire	1,160,558	417,801	36	1,148,952	99	11,606	1	31
Vermont	4,716,306	2,310,990	49	4,669,143	99	47,163	1	30
Massachusetts	549,864	109,973	20	549,864	100			31
Rhode Island	112,950	48,568	43	111,820	99	1,130	1	28
Connecticut	641,016	243,586	38	641,016	100			29
New York	49,916,064	26,954,675	54	45,423,618	91	4,492,446	9	31
New Jersey	3,620,490	1,810,245	50	3,149,826	87	470,664	13	30
Pennsylvania	36,086,821	16,960,806	47	31,395,534	87	4,691,287	13	31
Delaware	548,071	208,267	38	460,380	84	87,691	16	30
Maryland	2,040,192	612,058	30	1,550,546	76	489,646	24	29
Virginia	8,492,296	3,142,150	37	7,388,298	87	1,103,998	13	29
North Carolina	5,777,256	1,444,314	25	5,430,621	94	346,635	6	30
South Carolina	2,954,798	295,480	10	2,895,702	98	59,096	2	31
Georgia	5,085,288	1,017,058	20	4,983,582	98	101,706	2	30
Florida	549,732	109,946	20	527,743	96	21,989	4	29
Alabama	4,454,870	801,877	18	4,365,773	98	89,097	2	30
Mississippi	1,599,273	223,898	14	1,567,288	98	31,985	2	30
Louisiana	345,450	17,272	5	345,450	100			29
Texas	12,668,860	2,027,018	16	10,895,220	86	1,773,640	14	29
Arkansas	5,075,456	1,167,355	23	5,024,701	99	50,755	1	27
Tennessee	7,205,418	2,233,680	31	6,124,605	85	1,080,813	15	30
West Virginia	3,847,872	1,462,191	38	3,655,478	95	192,394	5	30
Kentucky	10,515,981	3,785,753	36	9,464,383	90	1,051,598	10	29
Ohio	32,553,689	14,649,160	45	24,415,267	75	8,138,422	25	29
Michigan	30,079,260	13,234,874	44	21,055,482	70	9,023,778	30	30
Indiana	34,433,237	12,395,965	36	23,758,934	69	10,674,303	31	28
Illinois	84,581,952	36,370,239	43	38,061,878	45	46,520,074	55	27
Wisconsin	65,257,675	32,628,838	50	46,985,526	72	18,272,149	28	31
Minnesota	56,766,336	28,950,831	51	41,439,425	73	15,326,911	27	31
Iowa	105,641,855	49,651,672	47	64,441,532	61	41,200,323	39	26
Missouri	19,850,490	7,146,176	36	17,468,431	88	2,382,059	12	24
Kansas	23,808,759	8,094,978	34	19,999,358	84	3,809,401	16	24
Nebraska	34,092,631	18,750,947	55	24,887,621	73	9,205,010	27	23
South Dakota	17,957,445	10,056,169	56	14,904,679	83	3,052,766	17	30
North Dakota	11,238,788	5,169,842	46	10,227,297	91	1,011,491	9	32
Montana	3,050,770	1,281,323	42	2,288,078	75	762,692	25	35
Wyoming	417,312	150,232	36	383,927	92	33,385	8	39
Colorado	2,600,724	988,275	38	1,820,507	70	780,217	30	35
New Mexico	221,157	101,732	46	110,579	50	110,578	50	33
Arizona								34
Utah	958,132	411,997	43	641,948	67	316,184	33	33
Nevada								37
Idaho	1,302,168	572,954	44	833,388	64	468,780	36	36
Washington	3,017,772	754,443	25	1,569,241	52	1,448,531	48	33
Oregon	3,854,319	925,037	24	2,698,023	70	1,156,296	30	35
California	1,827,171	365,434	20	1,425,193	78	401,978	22	34
Oklahoma								28
Total	707,346,404	312,814,923	44.2	516,703,544	73	190,642,860	27	28.6

The following table shows the number of acres devoted to certain principal crops for every 1,000 acres of improved land in 1879 and 1889, as determined by the Tenth and Eleventh Censuses:

Changes in acreage of principal crops.

Crop.	1879.	1889.	Increase or decrease.	Crop.	1879.	1889.	Increase or decrease.
	Acres.	*Acres.*	*Acres.*		*Acres.*	*Acres.*	*Acres.*
Corn	219.0	201.6	Decrease 17.4	Hay	107.6	148.1	Increase 40.5
Wheat	124.4	93.9	Decrease 30.5	Cotton	50.7	56.2	Increase 5.5
Oats	56.7	79.2	Increase 22.5				
Barley	7.0	9.0	Increase 2.0	Total area in these products.	574.9	596.5	Net increase 21.6
Rye	6.5	6.1	Decrease .4				
Buckwheat	3.0	2.4	Decrease .6				

It is thus shown that for every 1,000 acres of improved land in 1889 there were 48.9 fewer acres in corn, wheat, rye, and buckwheat, and 70.5 more in oats, hay, barley, and cotton than for the corresponding area in 1879.

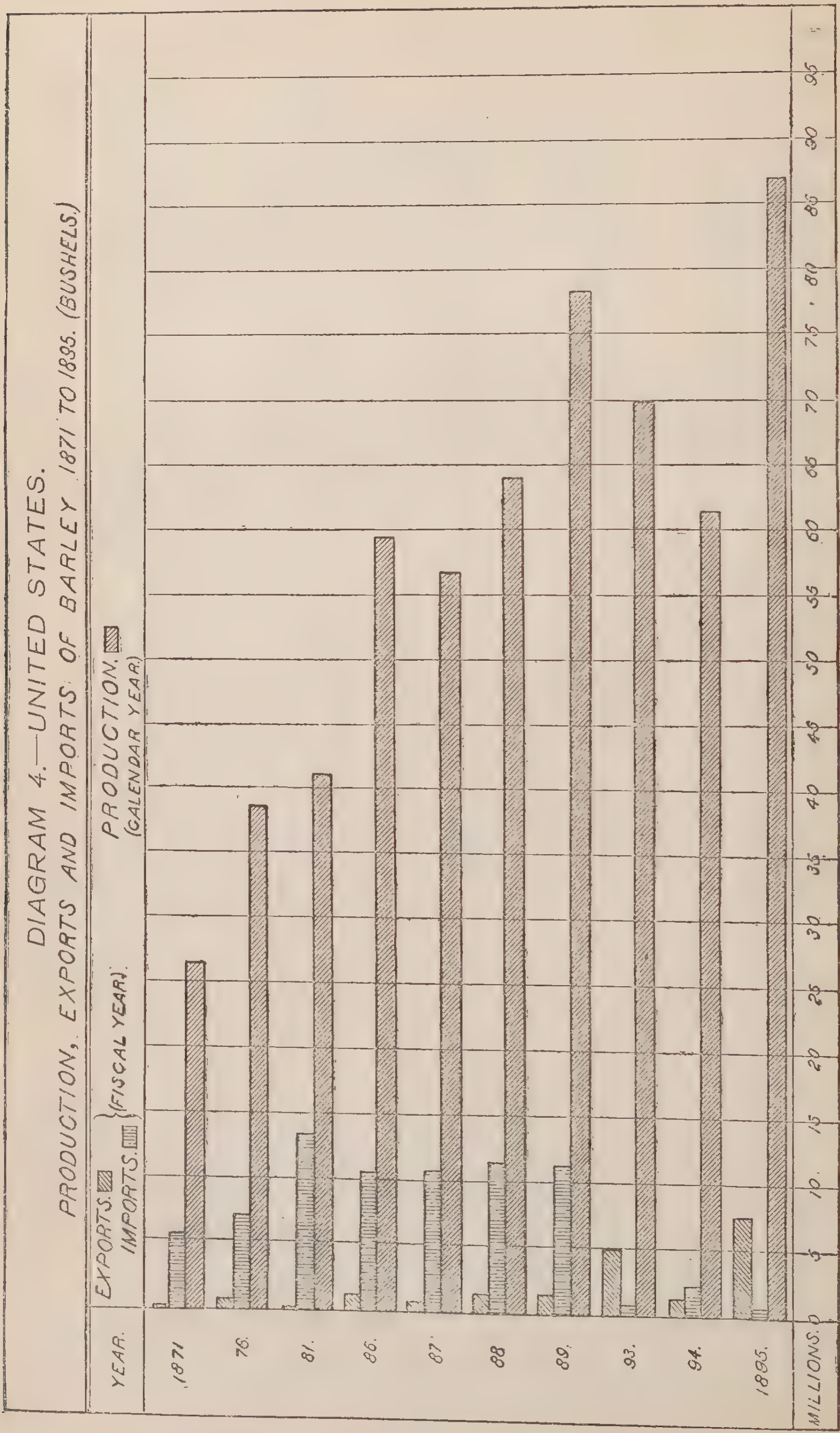


DIAGRAM 4.—UNITED STATES.
PRODUCTION, EXPORTS AND IMPORTS OF BARLEY 1871 TO 1895. (BUSHELS.)

[NOTE.—The exports and imports are for the twelve months *beginning* July 1 of the year set opposite to them.]

Acreage, production, and value of oats and barley in 1896.

State or Territory.	Oats.			Barley.		
	Acres.	Bushels.	Value.	Acres.	Bushels.	Value.
Maine	146,747	5,869,880	$1,819,663	12,355	378,063	$162,567
New Hampshire	30,541	1,160,558	406,195	5,335	156,316	82,847
Vermont	116,452	4,716,306	1,462,055	18,295	603,735	247,531
Massachusetts	15,274	549,864	192,452	1,839	55,170	31,999
Rhode Island	3,765	112,950	35,014	381	11,049	6,629
Connecticut	22,104	641,016	198,715			
New York	1,512,608	49,916,064	12,978,177	212,714	4,934,965	1,924,636
New Jersey	106,485	3,620,490	1,013,737			
Pennsylvania	1,164,091	36,086,821	8,660,837	10,251	176,317	70,527
Delaware	18,899	548,071	115,095			
Maryland	85,008	2,040,192	469,244			
Virginia	459,043	8,492,296	2,207,997			
North Carolina	481,438	5,777,256	2,022,010			
South Carolina	268,618	2,954,798	1,418,303			
Georgia	423,774	5,085,288	2,084,968			
Florida	45,811	549,732	291,358			
Alabama	318,205	4,454,870	1,826,497			
Mississippi	123,021	1,599,273	703,680			
Louisiana	34,545	345,450	117,453			
Texas	633,443	12,668,860	4,307,412	2,360	28,320	14,160
Arkansas	317,216	5,075,456	1,573,391			
Tennessee	436,692	7,205,418	1,873,409	1,993	27,902	12,556
West Virginia	160,328	3,847,872	1,077,404			
Kentucky	500,761	10,515,981	2,523,835	1,844	27,291	10,916
Ohio	1,050,119	32,553,689	5,534,127	27,197	549,379	208,764
Michigan	1,002,642	30,079,260	5,715,059	57,565	1,283,700	539,154
Indiana	1,187,353	34,433,237	5,509,318	5,449	110,615	36,503
Illinois	3,020,784	84,581,952	12,687,293	17,292	409,820	127,044
Wisconsin	1,864,505	65,257,675	11,093,805	326,425	8,944,045	2,414,892
Minnesota	1,720,192	56,766,336	8,514,950	416,557	11,330,350	2,266,070
Iowa	3,841,522	105,641,855	12,677,023	389,607	10,246,664	2,151,799
Missouri	1,102,805	19,850,490	3,374,583	799	13,983	3,496
Kansas	1,831,443	23,808,759	3,809,401	18,839	86,659	19,065
Nebraska	1,794,349	34,092,631	3,750,189	45,617	907,778	172,478
South Dakota	652,998	17,957,445	2,334,468	116,096	3,308,736	628,660
North Dakota	510,854	11,238,788	2,022,982	235,520	3,791,872	796,293
Montana	64,910	3,050,770	945,739	5,701	142,525	78,389
Wyoming	13,041	417,312	221,175			
Colorado	92,883	2,600,724	780,217	12,861	257,220	118,321
New Mexico	8,191	221,157	88,463	1,241	23,579	15,326
Utah	25,214	958,132	373,671	6,366	172,519	72,458
Idaho	31,004	1,302,168	390,650	10,606	162,272	35,700
Washington	83,827	3,017,772	1,207,109	40,094	1,042,444	416,978
Oregon	183,539	3,854,319	1,271,925	30,956	674,841	303,678
California	58,941	1,827,171	803,955	918,384	19,837,094	9,521,805
Total	27,565,985	707,346,404	132,485,033	2,950,539	39,695,223	22,491,241

Production of oats for the years 1894 to 1896.

Year.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*	*Dollars.*	*Cents.*	*Bushels.*	*Dollars.*
1894	662,036,928	27,023,553	214,816,920	32.4	24.5	7.95
1895	824,443,537	27,878,406	163,655,068	19.9	29.6	5.87
1896	707,346,404	27,565,985	132,485,033	18.7	25.7	4.81

Our exports of oats (including oatmeal reduced at the rate of 18 pounds to the bushel) rarely exceed 1 per cent of the total crop, the highest ratio being 2.1 per cent, for the fiscal year 1895–96.

The barley acreage in 1895 was the largest on record, and the average yield per acre was the highest in a quarter of a century.

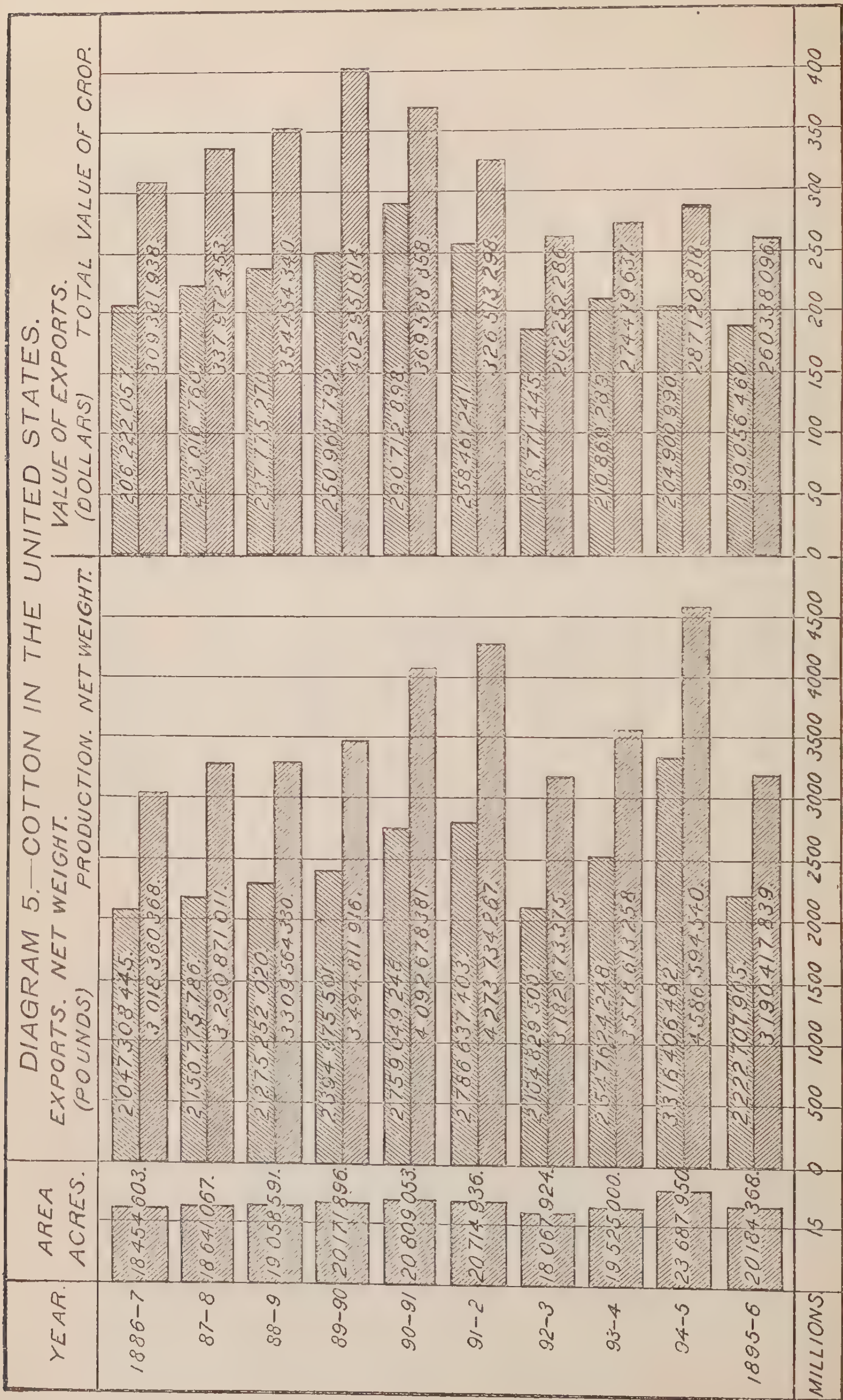
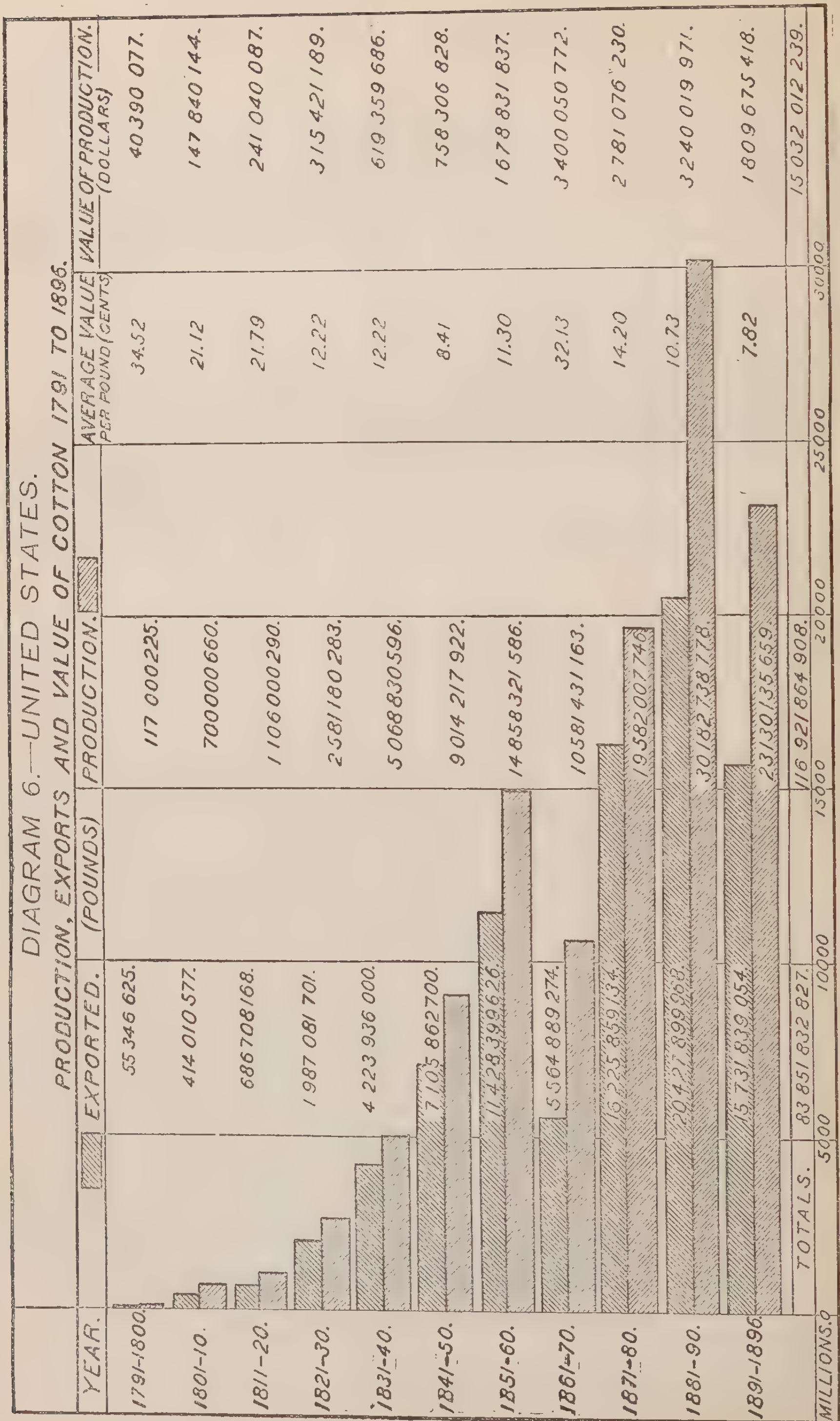


DIAGRAM 5.—COTTON IN THE UNITED STATES.
YEAR.
AREA ACRES.
EXPORTS. NET WEIGHT.
PRODUCTION. NET WEIGHT.
(POUNDS)
VALUE OF EXPORTS.
TOTAL VALUE OF CROP.
(DOLLARS)
1886–7
87–8
88–9
89–90
90–91
91–2
92–3
93–4
94–5
1895–6
18 454 603.
18 641 067.
19 058 591.
20 171 896.
20 809 053.
20 714 936.
18 067 924.
19 525 000.
23 687 950.
20 184 368.
2 047 308 445.
3 018 360 368.
2 150 775 786.
3 290 871 011.
2 275 852 020.
3 309 564 330.
2 394 675 501.
3 494 811 916.
2 759 049 240.
4 092 678 381.
2 786 637 403.
4 273 734 267.
2 104 829 500.
3 182 673 375.
2 547 624 248.
3 578 613 258.
3 316 406 482.
4 586 594 540.
2 222 707 905.
3 190 417 839.
206 222 057.
309 381 938.
223 016 760.
337 972 453.
237 775 270.
354 454 340.
250 968 792.
402 951 814.
290 712 898.
369 568 858.
258 461 241.
326 513 298.
188 771 445.
262 252 286.
210 869 289.
274 479 637.
204 900 990.
287 120 818.
190 056 460.
260 338 096.
MILLIONS
15
0
500
1000
1500
2000
2500
3000
3500
4000
4500
0
50
100
150
200
250
300
350
400

Wheat crop of the world for the years 1892 to 1896.

Country.	1892.	1893.	1894.	1895.	1896.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
United States	515,949,000	396,132,000	460,267,000	467,103,000	427,684,000
Canada	49,701,000	42,650,000	44,583,000	57,460,000	40,809,000
Mexico	14,000,000	15,000,000	18,000,000	14,000,000	8,000,000
Total North America	579,650,000	453,782,000	522,850,000	538,563,000	476,493,000
Argentina	36,000,000	57,000,000	80,000,000	60,000,000	48,000,000
Uruguay	3,292,000	5,703,000	8,915,000	10,000,000	6,000,000
Chile	16,500,000	19,000,000	16,000,000	15,000,000	12,000,000
Total South America	55,792,000	81,703,000	104,915,000	85,000,000	66,000,000
Austria	50,174,000	43,660,000	48,190,000	41,767,000	43,991,000
Hungary	142,558,000	158,425,000	141,858,000	146,000,000	150,660,000
Croatia-Slavonia	7,071,000	8,223,000	8,786,000	6,200,000	8,000,000
Bosnia-Herzegovina	2,000,000	2,000,000	2,000,000	2,000,000	2,050,000
Montenegro	250,000	250,000	250,000	220,000	220,000
Servia	10,000,000	8,651,000	7,500,000	9,400,000	9,300,000
Roumania	63,942,000	60,115,000	43,587,000	68,503,000	69,200,000
Turkey in Europe	20,000,000	20,000,000	20,000,000	21,500,000	24,000,000
Bulgaria	40,441,000	35,987,000	30,600,000	37,000,000	45,600,000
Greece	4,500,000	6,500,000	5,500,000	4,000,000	4,800,000
Italy	115,685,000	135,227,000	121,595,000	106,181,000	132,000,000
Spain	82,288,000	93,484,000	105,600,000	92,000,000	83,000,000
Portugal	6,000,000	5,500,000	9,000,000	7,000,000	5,600,000
France	310,836,000	277,509,000	347,537,000	339,129,000	337,823,000
Switzerland	4,000,000	3,300,000	4,500,000	5,000,000	4,800,000
Germany	116,215,000	110,040,000	110,681,000	103,159,000	106,140,000
Belgium	19,500,000	17,300,000	19,800,000	18,000,000	17,216,000
Netherlands	5,380,000	4,971,000	4,346,000	5,000,000	5,400,000
Great Britain	60,407,000	50,800,000	61,038,000	38,348,000	58,851,000
Ireland	2,214,000	1,666,000	1,532,000	1,109,000	1,191,000
Denmark	4,964,000	4,661,000	4,162,000	4,591,000	4,340,000
Sweden	4,343,000	3,893,000	4,467,000	3,798,000	4,671,000
Norway	250,000	275,000	275,000	260,000	300,000
Russia in Europe	337,570,000	461,861,000	418,225,000	376,885,000	365,148,000
Total Europe	1,410,588,000	1,514,298,000	1,521,029,000	1,437,050,000	1,484,301,000
Russia in Asia	72,000,000	76,997,000	87,608,000	83,499,000	75,000,000
British India	206,640,000	268,539,000	252,784,000	234,379,000	181,997,000
Asiatic Turkey	44,000,000	48,000,000	45,000,000	46,000,000	44,000,000
Persia	18,567,000	20,000,000	22,000,000	22,000,000	20,000,000
Japan	15,741,000	16,848,000	20,310,000	16,500,000	16,000,000
Cyprus	2,000 000	2,000,000	2,000,000	2,200,000	2,400,000
Total Asia	358,948,000	432,384,000	429,702,000	404,578,000	339,397,000
Egypt	8,252,000	10,000,000	12,000,000	14,000,000	12,000,000
Tunis	8,000,000	4,000,000	10,700,000	7,500,000	5,600,000
Algeria	19,979,000	20,274,000	28,900,000	24,800,000	17,600,000
Cape Colony	3,500,000	4,014,000	3,195,000	2,542,000	3,200,000
Total Africa	39,731,000	38,288,000	54,795,000	48,842,000	38,400,000
New South Wales	4,089,000	7,032,000	6,708,000	7,263,000	5,359,000
Victoria	14,110,000	15,282,000	15,736,000	11,807,000	5,848,000
South Australia	6,639,000	9,531,000	14,047,000	8,027,000	6,116,000
Western Australia	305,000	443,000	537,000	176,000	194,000
Tasmania	967,000	1,051,000	860,000	899,000	1,202,000
New Zealand	10,581,000	8,642,000	5,046,000	3,727,000	7,059,000
Queensland	405,000	477,000	426,000	562,000	128,000
Total Australasia	37,096,000	42,458,000	43,360,000	32,461,000	25,906,000
Recapitulation by continents:					
North America	579,650,000	453,782,000	522,850,000	538,563,000	476,493,000
South America	55,792,000	81,703,000	104,915,000	85,000,000	66,000,000
Europe	1,410,588,000	1,514,298,000	1,521,029,000	1,437,050,000	1,484,301,000
Asia	358,948,000	432,384,000	429,702,000	404,578,000	339,397,000
Africa	39,731,000	38,288,000	54,795,000	48,842,000	38,400,000
Australasia	37,096,000	42,458,000	43,360,000	32,461,000	25,906,000
Grand total	2,481,805,000	2,562,913,000	2,676,651,000	2,546,494,000	2,430,497,000



YEAR.	EXPORTED. (POUNDS)	PRODUCTION.	AVERAGE VALUE PER POUND (CENTS)	VALUE OF PRODUCTION. (DOLLARS)
1791-1800.	55 346 625.	117 000 225.	34.52	40 390 077.
1801-10.	414 010 577.	700 000 660.	21.12	147 840 144.
1811-20.	686 708 168.	1 106 000 290.	21.79	241 040 087.
1821-30.	1 987 081 701.	2 581 180 283.	12.22	315 421 189.
1831-40.	4 223 936 000.	5 068 830 596.	12.22	619 359 686.
1841-50.	7 105 862 700.	9 014 217 922.	8.41	758 306 828.
1851-60.	11 428 399 626.	14 858 321 586.	11.30	1 678 831 837.
1861-70.	5 564 889 274.	10 581 431 163.	32.13	3 400 050 772.
1871-80.	16 225 859 134.	19 582 007 746.	14.20	2 781 076 230.
1881-90.	20 427 899 968.	30 182 738 778.	10.73	3 240 019 971.
1891-1896.	15 731 839 954.	23 130 135 659.	7.82	1 809 675 418.
TOTALS.	83 851 832 827.	116 921 864 908.		15 032 012 239.

Acreage, production, and value of potatoes and hay in 1896.

State or Territory.	Potatoes.			Hay.		
	Acres.	Bushels.	Value.	Acres.	Tons.	Value.
Maine	49,140	8,108,100	$3,081,078	939,192	939,192	$9,626,718
New Hampshire	20,588	2,223,504	1,045,047	590,527	566,906	7,313,087
Vermont	27,337	3,499,136	1,014,749	843,831	1,054,789	10,843,231
Massachusetts	26,854	2,900,232	1,653,132	573,731	734,376	12,043,766
Rhode Island	6,518	684,390	369,571	72,350	79,585	1,321,111
Connecticut	24,347	2,580,782	1,187,160	456,973	488,961	7,192,616
New York	385,999	34,353,911	10,649,712	4,239,788	3,434,228	41,348,105
New Jersey	46,605	4,324,470	1,556,809	396,354	455,807	6,510,830
Pennsylvania	194,322	21,181,098	5,718,896	2,559,250	2,712,805	32,960,581
Delaware	5,086	396,708	138,848	50,942	56,036	728,468
Maryland	23,936	2,154,240	646,272	314,134	273,297	3,238,569
Virginia	38,618	3,591,474	1,221,101	589,520	636,682	6,500,523
North Carolina	18,309	1,446,411	621,957	140,965	177,616	1,909,372
South Carolina	4,460	231,920	153,067	143,536	190,903	2,161,022
Georgia	5,524	303,820	227,865	137,489	189,735	2,096,572
Florida	1,308	98,100	82,404	6,719	9,407	122,291
Alabama	6,859	438,976	329,232	65,989	92,385	905,373
Mississippi	5,886	412,020	255,452	61,656	83,236	787,413
Louisiana	9,301	511,555	388,782	24,721	46,970	410,988
Texas	12,904	671,008	523,386	324,622	324,622	2,337,278
Arkansas	24,886	1,468,274	778,185	159,010	187,632	1,414,745
Tennessee	34,359	2,130,258	852,103	352,719	493,807	4,775,114
West Virginia	38,294	3,561,342	1,104,016	484,751	591,396	5,789,767
Kentucky	46,353	3,940,005	1,300,202	385,399	462,479	4,375,051
Ohio	195,565	17,405,285	4,525,374	1,749,451	2,204,308	17,480,162
Michigan	208,381	18,337,528	3,484,130	1,330,061	1,542,871	13,083,546
Indiana	104,184	8,855,640	2,213,910	1,645,101	2,138,631	15,355,371
Illinois	173,204	16,800,788	4,368,205	2,058,647	2,840,933	18,153,562
Wisconsin	161,748	12,616,344	2,397,105	1,432,404	1,790,505	11,817,333
Minnesota	119,955	10,076,220	2,116,006	1,664,826	2,813,556	10,663,377
Iowa	213,410	20,060,540	4,413,319	4,612,583	8,025,894	32,023,317
Missouri	100,739	7,857,642	2,435,869	2,306,434	3,298,201	15,996,275
Kansas	108,202	7,465,938	2,015,803	3,473,167	4,931,897	13,316,122
Nebraska	126,478	11,383,020	2,845,755	1,957,835	3,250,006	7,930,015
South Dakota	63,004	6,048,384	1,209,677	2,096,344	2,683,320	8,371,958
North Dakota	32,453	3,310,206	695,143	441,094	727,805	2,467,259
Montana	4,952	841,840	269,389	345,584	476,906	3,271,575
Wyoming	2,758	460,586	198,052	236,003	365,805	2,611,848
Colorado	32,345	2,846,360	1,337,789	761,784	1,675,925	10,424,254
New Mexico	742	53,424	36,328	36,515	109,545	624,406
Arizona				32,344	103,501	905,634
Utah	5,572	863,660	276,371	181,371	489,702	2,448,510
Nevada	1,349	256,310	97,398	144,278	367,909	1,773,321
Idaho	3,888	629,856	188,957	193,139	502,161	2,365,178
Washington	14,250	1,781,250	712,500	292,025	569,449	4,037,393
Oregon	14,935	1,299,345	506,745	622,392	1,232,336	8,133,418
California	22,158	1,772,640	939,499	1,732,206	2,858,140	18,149,189
Total	2,767,465	252,234,540	72,182,350	43,259,756	59,282,153	388,145,614

Acreage, production, and value of potatoes and hay in the United States for the years 1893–1896.[1]

Year.	Potatoes.			Hay.		
	Acres.	Bushels.	Value.	Acres.	Tons.	Value.
1893	2,605,186	183,034,203	$108,661,801	49,613,469	65,766,158	$570,882,872
1894	2,737,973	170,787,338	91,526,787	48,321,272	54,874,408	468,578,321
1895	2,954,952	297,237,370	78,984,901	44,206,453	47,078,541	393,185,615
1896	2,767,465	252,234,540	72,182,350	43,259,756	59,282,158	388,145,614

[1] No estimates concerning these products were made by the Department of Agriculture for the years 1889–1892.

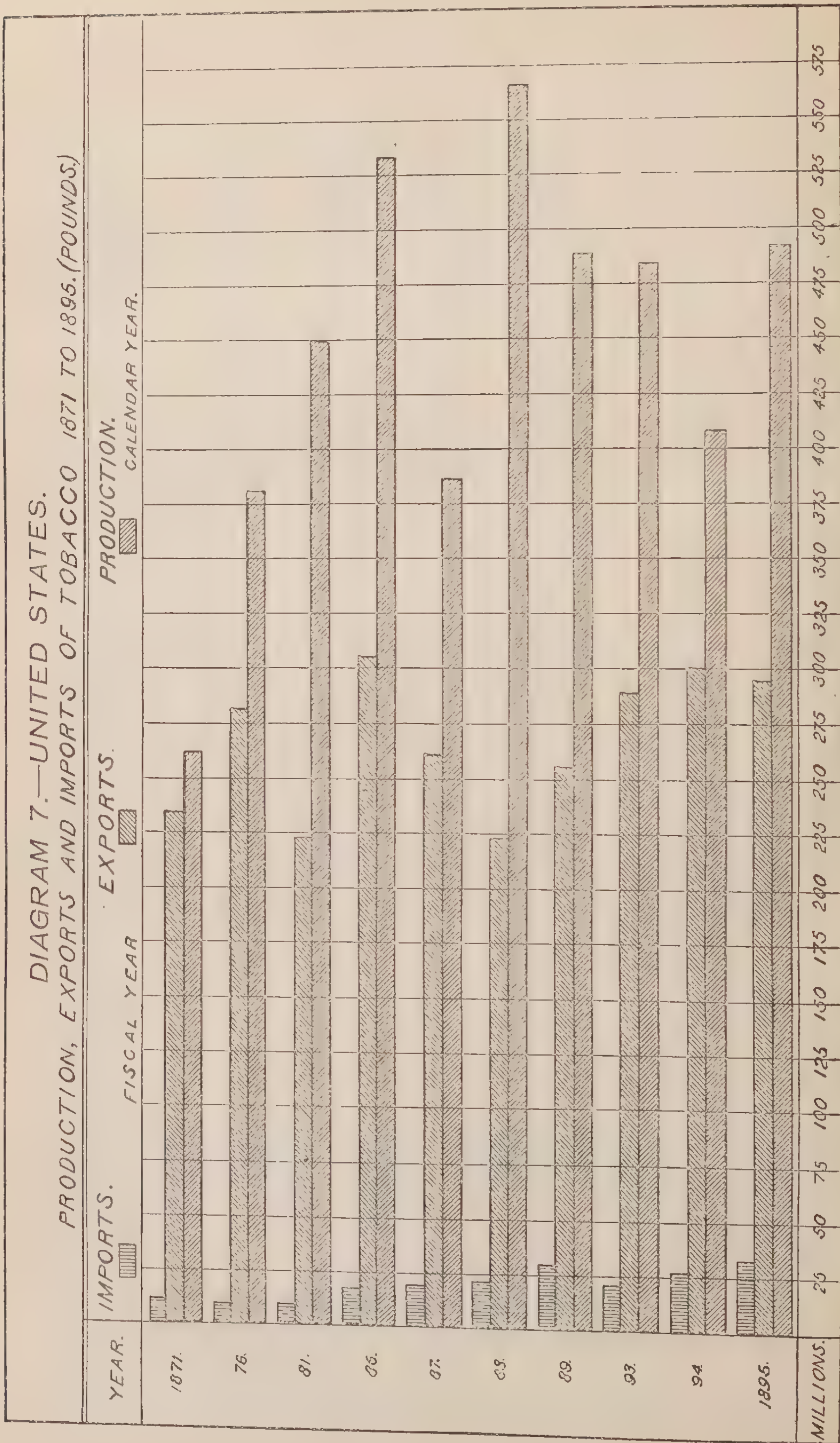


DIAGRAM 7.—UNITED STATES.

PRODUCTION, EXPORTS AND IMPORTS OF TOBACCO 1871 TO 1895. (POUNDS.)

[NOTE.—The exports and imports are for the twelve months *beginning* July 1 of the year set opposite to them.]

Acreage, production, etc., of the cotton crop of 1895.

State or Territory.	Acres.	Bales.	Bales per acre.	Net movement by rail and water.	Bought by mills.	Less stock on hand September 1, 1895.
Alabama	2,371,726	663,916	0.28	609,633	58,998	4,715
Arkansas	1,186,655	520,860	.44	522,827	1,975	3,942
Florida	191,540	38,722	.20	38,914		192
Georgia	3,069,323	1,067,377	.35	875,621	200,636	8,880
Indian Territory	212,847	68,668	.32	68,668		
Kansas	40	15	.38	15		
Louisiana	1,142,568	513,843	.45	503,341	13,344	2,842
Mississippi	2,487,119	1,013,358	.41	999,907	16,654	3,203
Missouri	47,772	11,816	.25	10,187	1,629	
North Carolina	1,050,183	397,752	.38	179,781	219,822	1,851
Oklahoma	26,093	14,103	.54	14,103		
South Carolina	1,814,728	764,700	.42	508,668	257,700	1,668
Tennessee	712,763	172,560	.24	144,462	28,732	634
Texas	5,826,428	1,905,337	.33	1,897,515	12,385	4,563
Utah	400	103	.26	103		
Virginia	44,623	7,964	.18	7,964	[1] (31,070)	
Total	20,184,808	7,161,094	.35	6,381,709	811,875	32,490

[1] All cotton used by Virginia mills was obtained from other States, and is therefore not included in the total.

Acreage, production, and value of tobacco in 1896.

State or Territory.	Tobacco.		
	Acres.	Pounds.	Value.
Massachusetts	1,975	3,199,500	$383,940
Connecticut	6,579	10,197,450	1,325,668
New York	3,259	3,389,360	271,149
Pennsylvania	13,884	16,244,280	1,299,542
Maryland	15,995	9,277,100	398,915
Virginia	92,002	57,961,260	3,013,986
North Carolina	134,567	68,629,170	5,490,334
Alabama	2,147	1,009,090	161,454
Arkansas	2,950	1,327,500	146,025
Tennessee	53,351	35,211,660	2,464,816
West Virginia	5,119	3,685,680	313,283
Kentucky	196,745	143,623,850	6,032,202
Ohio	32,012	23,688,880	1,066,000
Indiana	11,957	8,130,760	365,884
Illinois	3,902	2,497,280	237,242
Wisconsin	3,975	5,088,000	279,840
Missouri	10,580	7,406,000	666,540
All other	3,750	2,437,500	341,250
Total	594,749	403,004,320	24,258,070

Average farm price of various agricultural products on December 1 in each year from 1887 to 1896.

Crop.	1896.	1895.	1894.	1893.	1892.	1891.	1890.	1889.	1888.	1887.
Corn ....per bushel	$0.215	$0.253	$0.457	$0.365	$0.393	$0.406	$0.506	$0.283	$0.341	$0.444
Wheat ....do	.726	.509	.491	.538	.624	.839	.838	.698	.926	.681
Rye ....do	.409	.440	.501	.513	.548	.774	.629	.457	.591	.544
Oats ....do	.187	.199	.324	.294	.317	.315	.424	.230	.278	.304
Barley ....do	.323	.337	.442	.411	.472	.540	.648	.427	.596	.522
Buckwheat ....do	.392	.452	.556	.583	.534	.579	.577	.518	.636	.561
Irish potatoes ....do	.286	.266	.536	.590	.673	.371	.777	.403	.404	.685
Hay ....per ton	6.55	8.35	8.54	8.68	8.49	8.39	7.74	7.88		9.34
Cotton ....per pound	.066	.076	.046	.070	.084	.073	.086	.083	.085	.085
Leaf tobacco ....do	.06	.069	.068	.081		.084	.077	.071		.103

Estimated number of horses and mules on farms and ranches, average price per head, and total value of each kind, January, 1897.

State or Territory.	Horses.			Mules.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	115,426	$46.58	$5,376,791			
New Hampshire	55,033	47.74	2,627,428			
Vermont	88,319	45.03	3,977,151			
Massachusetts	63,800	64.67	4,125,946			
Rhode Island	10,129	75.25	762,210			
Connecticut	43,035	61.31	2,638,558			
New York	621,343	49.67	30,862,898	4,534	$55.07	$249,701
New Jersey	80,788	58.98	4,764,706	7,492	76.73	574,876
Pennsylvania	583,215	44.27	25,819,103	36,144	58.81	2,125,529
Delaware	30,274	42.76	1,294,516	5,269	59.75	314,838
Maryland	133,645	38.25	5,111,360	12,817	58.14	745,227
Virginia	243,586	36.42	8,870,380	37,483	48.58	1,820,890
North Carolina	145,536	44.76	6,514,890	110,860	49.98	5,541,305
South Carolina	66,449	48.23	3,204,877	98,834	61.68	6,096,201
Georgia	110,277	48.34	5,331,018	164,380	62.93	10,343,698
Florida	35,865	42.70	1,531,331	8,273	59.48	492,084
Alabama	129,619	38.82	5,032,297	129,739	49.01	6,358,007
Mississippi	195,571	35.19	6,882,938	160,032	48.81	7,811,371
Louisiana	141,464	27.26	3,855,824	88,239	52.83	4,661,317
Texas	1,160,101	17.73	20,571,962	261,428	29.83	7,799,259
Arkansas	240,330	26.45	6,356,207	145,519	34.26	4,985,923
Tennessee	337,551	36.41	12,290,744	169,389	39.17	6,635,682
West Virginia	156,511	33.28	5,209,206	7,601	38.27	290,898
Kentucky	400,879	32.57	13,056,621	116,854	33.97	3,969,482
Ohio	701,933	36.67	25,737,791	18,501	38.59	713,872
Michigan	427,333	43.14	18,437,058	2,784	37.59	104,659
Indiana	645,834	31.81	20,547,082	46,397	36.08	1,674,144
Illinois	1,072,956	30.91	33,166,042	90,631	35.69	3,234,290
Wisconsin	420,710	40.95	17,229,021	4,826	37.72	182,024
Minnesota	469,101	35.95	16,864,237	8,631	41.59	358,957
Iowa	1,087,492	28.94	31,469,631	33,704	35.46	1,195,015
Missouri	854,126	24.79	21,175,838	215,466	29.91	6,445,651
Kansas	797,744	23.54	18,780,168	82,269	31.04	2,553,469
Nebraska	575,714	24.68	14,207,318	41,961	32.33	1,356,689
South Dakota	290,775	26.50	7,706,063	6,660	30.94	206,090
North Dakota	166,702	36.43	6,072,302	7,151	48.03	343,461
Montana	175,301	24.38	4,272,970	924	31.46	29,067
Wyoming	77,614	13.12	1,018,683	1,474	35.97	53,019
Colorado	159,706	20.06	3,204,212	8,888	42.81	380,454
New Mexico	84,701	14.65	1,240,873	3,560	19.19	68,308
Arizona	52,498	21.59	1,133,429	1,026	25.16	25,815
Utah	71,178	16.97	1,207,941	1,648	24.43	40,264
Nevada	53,561	18.06	967,320	1,444	32.39	46,769
Idaho	132,011	17.12	2,259,370	941	15.59	14,673
Washington	176,691	20.47	3,616,227	1,420	39.21	55,677
Oregon	203,777	18.18	3,704,688	5,811	21.92	127,404
California	439,364	27.40	12,037,918	57,473	36.89	2,120,329
Oklahoma	39,099	13.41	524,222	7,177	21.69	155,702
Total	14,364,667	31.51	452,649,396	2,215,654	41.66	92,302,090
Total, 1896	15,124,057	33.07	500,140,186	2,278,946	45.29	103,204,457
Decrease	759,390	1.56	47,490,790	63,292	3.63	10,902,367
Decrease (per cent)	5	4.7	9.5	2.8	8	10.6

Number and value of horses, mules, and milch cows in the United States for the years 1891 to 1897.

January 1—	Horses.		Mules.		Milch cows.	
	Number.	Value.	Number.	Value.	Number.	Value.
1891	14,056,750	$941,823,222	2,296,532	$178,847,370	16,019,591	$346,397,900
1892	15,498,140	1,007,593,636	2,314,699	174,882,070	16,416,351	351,378,132
1893	16,206,802	992,225,185	2,331,128	164,763,751	16,424,087	357,299,785
1894	16,081,139	769,224,799	2,352,231	146,232,811	16,487,400	358,998,661
1895	15,893,318	576,730,580	2,333,108	110,927,834	16,504,629	362,601,729
1896	15,124,057	500,140,186	2,278,946	103,204,457	16,137,586	363,955,545
1897	14,364,667	452,649,396	2,215,654	92,302,090	15,941,727	369,239,993

Estimated number of milch cows and of oxen and other cattle on farms and ranches, average price per head, and total value of each kind, January, 1897.

State or Territory.	Milch cows.			Oxen and other cattle.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	192,077	$25.06	$4,813,450	108,378	$20.13	$2,181,493
New Hampshire	128,971	27.12	3,497,694	77,098	19.89	1,533,410
Vermont	263,640	24.57	6,477,635	137,897	19.19	2,646,257
Massachusetts	172,826	30.78	5,319,584	75,647	24.33	1,840,485
Rhode Island	24,763	30.00	742,890	10,784	24.29	261,892
Connecticut	136,206	27.73	3,776,992	66,614	25.31	1,686,322
New York	1,416,327	24.20	34,275,113	561,582	20.84	11,700,564
New Jersey	206,357	32.27	6,659,140	45,113	23.02	1,038,486
Pennsylvania	938,288	25.93	24,329,808	568,022	21.62	12,278,880
Delaware	34,857	27.50	958,568	25,482	21.13	538,434
Maryland	150,477	22.81	3,432,380	113,724	22.36	2,543,205
Virginia	260,322	17.89	4,657,161	371,208	15.42	5,723,360
North Carolina	266,605	13.75	3,665,819	345,406	9.55	3,300,322
South Carolina	129,388	15.83	2,048,212	156,866	8.85	1,387,622
Georgia	306,457	17.01	5,212,834	513,870	8.46	4,347,650
Florida	116,619	16.48	1,921,881	353,833	6.81	2,408,150
Alabama	305,355	11.12	3,395,548	491,929	6.88	3,384,129
Mississippi	290,931	12.85	3,738,463	446,839	8.03	3,589,456
Louisiana	153,538	15.25	2,341,454	268,425	8.65	2,321,531
Texas	752,579	16.43	12,364,873	5,242,712	11.14	58,417,443
Arkansas	266,244	12.43	3,309,413	418,523	8.07	3,377,357
Tennessee	307,542	15.93	4,899,144	456,829	10.74	4,907,805
West Virginia	171,528	21.17	3,631,248	266,952	16.79	4,481,825
Kentucky	285,461	19.78	5,646,419	461,367	17.71	8,168,601
Ohio	752,001	25.18	18,935,385	631,382	22.39	14,135,761
Michigan	459,153	26.57	12,199,695	370,750	19.09	7,076,135
Indiana	618,282	23.72	14,665,649	726,557	21.08	15,317,115
Illinois	1,008,259	28.50	28,735,382	1,330,808	23.49	31,264,395
Wisconsin	786,844	23.98	18,868,519	632,855	16.71	10,574,004
Minnesota	618,530	23.51	14,541,640	652,662	15.98	10,430,321
Iowa	1,190,534	28.14	33,501,627	2,196,755	24.99	54,901,306
Missouri	701,610	22.91	16,073,885	1,568,901	20.74	32,545,606
Kansas	629,121	24.50	15,413,464	1,801,570	21.72	39,133,349
Nebraska	534,197	24.63	13,157,272	1,019,970	19.53	19,918,494
South Dakota	313,375	22.93	7,185,689	427,801	20.03	8,568,564
North Dakota	161,268	21.79	3,514,030	255,502	17.82	4,553,911
Montana	42,928	25.83	1,108,830	1,176,628	17.60	20,708,660
Wyoming	18,515	25.25	467,504	781,923	17.07	13,347,431
Colorado	82,374	26.11	2,150,785	926,560	19.47	18,044,569
New Mexico	18,751	22.60	423,773	753,831	11.76	8,864,297
Arizona	16,872	22.55	380,464	547,400	12.02	6,577,011
Utah	56,698	17.95	1,017,729	358,293	13.77	4,933,162
Nevada	18,196	26.80	487,653	253,896	16.32	4,143,128
Idaho	28,595	23.10	660,544	387,935	15.07	5,846,179
Washington	120,902	23.46	2,836,361	351,026	15.10	5,301,224
Oregon	116,007	21.80	2,528,953	741,145	13.55	10,043,483
California	339,002	25.57	8,668,281	853,279	16.93	14,448,828
Oklahoma	32,355	18.58	601,156	175,879	18.13	3,187,809
Total	15,941,727	23.16	369,239,993	30,508,408	16.65	507,929,421
Total, 1896	16,137,586	22.55	363,955,545	32,085,409	15.86	508,928,416
Decrease	195,859	[1] .61	[1] 5,284,448	1,577,001	[1] .79	998,995
Decrease (per cent)	1.2	[1] 2.7	[1] 1.5	4.9	[1] 5	.2

[1] Increase.

Progress of dairying in the United States.

[From the reports of the Census.]

Year of census.	Milch cows.		Butter, total amount made.	Cheese, total amount made.	Creameries and cheese factories.	Milk, average yield per cow.
	Total number.	Per 1,000 persons.				
			Pounds.	*Pounds.*	*Number.*	*Gallons.*
1890	16,511,950	264	1,205,508,384	256,761,883	4,712	315.4
1880	12,443,120	248	806,672,071	243,157,850	3,932	232.5
1870	8,935,332	232	514,092,683	162,927,382	[1] 1,313	205.9
1860	8,585,735	273	459,681,372	103,663,927	[2] 5	174.7
1850	6,385,094	275	313,345,306	105,535,893	[1] 8	166.5

[1] Cheese factories only.
[2] The establishments reported for 1850, 1860, and 1870 were all cheese factories. The figures for 1850 are approximately correct, but those for 1860 are known to be much too small.

Estimated number of sheep and swine on farms and ranches, average price per head, and total value of each kind, January, 1897.

State or Territory.	Sheep.			Swine.		
	Number.	Average price.	Value.	Number.	Average price.	Value.
Maine	230,364	$2.05	$471,671	76,835	$5.94	$456,092
New Hampshire	77,529	2.33	180,332	55,272	8.97	495,790
Vermont	157,948	2.02	318,423	76,215	7.29	555,791
Massachusetts	42,104	3.38	142,206	58,297	8.44	492,025
Rhode Island	10,715	2.81	30,136	14,289	7.00	100,024
Connecticut	32,104	3.09	99,041	53,737	9.29	498,999
New York	809,261	2.68	2,166,797	632,524	6.61	4,181,932
New Jersey	41,482	3.27	135,597	153,437	8.02	1,230,872
Pennsylvania	798,751	2.77	2,209,984	1,022,773	6.67	6,822,816
Delaware	12,358	3.14	38,779	49,559	5.80	287,443
Maryland	124,689	2.66	331,361	331,886	6.74	2,237,741
Virginia	392,738	2.14	840,774	995,005	3.38	3,361,164
North Carolina	319,170	1.39	443,966	1,455,892	3.11	4,524,475
South Carolina	72,976	1.56	114,134	1,095,968	3.49	3,830,172
Georgia	344,680	1.46	503,646	2,012,868	3.17	6,373,544
Florida	97,706	1.58	154,610	415,017	2.02	837,504
Alabama	252,133	1.25	316,074	1,885,876	2.53	4,763,724
Mississippi	306,156	1.37	420,252	1,998,978	2.40	4,790,752
Louisiana	136,311	1.22	166,885	790,961	2.83	2,235,255
Texas	2,789,383	1.20	3,350,607	2,944,065	2.48	7,301,281
Arkansas	170,075	1.28	218,512	1,375,586	2.32	3,196,861
Tennessee	382,335	1.44	549,836	1,796,104	3.33	5,978,152
West Virginia	458,157	2.18	1,000,065	371,292	4.25	1,577,100
Kentucky	738,195	1.90	1,405,229	1,604,164	3.34	5,359,192
Ohio	2,368,967	2.48	5,877,171	2,284,662	4.93	11,273,436
Michigan	1,341,971	2.64	3,536,899	713,487	5.92	4,220,277
Indiana	654,758	2.71	1,771,579	1,340,365	5.05	6,762,409
Illinois	604,189	2.86	1,725,564	2,249,401	5.18	11,651,896
Wisconsin	708,722	2.37	1,679,104	902,507	5.38	4,859,097
Minnesota	404,904	2.19	887,711	521,690	4.91	2,560,977
Iowa	553,834	3.02	1,672,578	3,737,970	5.67	21,182,330
Missouri	697,264	1.90	1,326,197	3,074,329	3.99	12,269,648
Kansas	222,215	1.80	398,965	1,659,722	4.61	7,648,165
Nebraska	188,768	2.47	466,182	1,263,931	4.77	6,026,422
South Dakota	336,259	2.17	731,161	158,463	4.39	696,128
North Dakota	356,230	1.95	695,219	120,308	4.50	541,385
Montana	3,122,732	1.61	5,033,220	51,045	7.87	401,486
Wyoming	1,672,432	1.80	3,005,862	17,734	4.52	80,122
Colorado	1,411,382	1.76	2,486,290	22,716	4.54	103,131
New Mexico	2,683,269	1.06	2,847,753	31,151	4.85	151,143
Arizona	828,666	1.57	1,301,172	26,076	4.84	126,208
Utah	1,998,441	1.52	3,036,830	53,790	5.45	293,382
Nevada	544,077	1.69	917,314	11,126	5.09	56,653
Idaho	1,376,119	1.71	2,346,283	75,192	3.69	277,721
Washington	741,219	1.86	1,375,851	210,683	3.32	700,310
Oregon	2,604,640	1.33	3,459,222	240,051	2.37	567,864
California	2,577,050	1.86	4,800,787	487,163	4.13	2,013,738
Oklahoma	23,215	1.42	33,011	78,514	4.08	320,141
Total	36,818,643	1.82	67,020,942	40,600,276	4.10	166,272,770
Total, 1896	38,298,783	1.70	65,167,735	42,842,759	4.35	186,529,745
Decrease	1,480,140	[1].12	[1]1,853,207	2,242,483	.25	20,256,975
Decrease (per cent)	3.9	[1]7.1	[1]2.8	5.2	5.7	10.9

[1] Increase.

Number and value of oxen and other cattle, and also of sheep and swine, with the total value of all farm animals in the United States, 1891 to 1897.

January 1	Oxen and other cattle.		Sheep.		Swine.		Total value of farm animals.
	Number.	Value.	Number.	Value.	Number.	Value.	
1891	36,875,648	$544,127,908	43,421,136	$108,397,447	50,625,106	$210,193,923	$2,329,787,770
1892	37,651,239	570,749,155	44,938,365	116,121,290	52,398,019	241,031,415	2,461,755,698
1893	35,954,196	547,882,204	47,273,553	125,909,264	46,094,807	295,426,492	2,483,506,681
1894	36,608,168	536,789,747	45,048,017	89,186,110	45,206,498	270,384,626	2,170,816,754
1895	34,364,216	482,999,129	42,294,064	66,685,767	44,165,716	219,501,267	1,819,446,306
1896	32,085,409	508,928,416	38,298,783	65,167,735	42,842,759	186,529,745	1,727,926,084
1897	30,508,408	507,929,421	36,818,643	67,020,942	40,600,276	166,272,770	1,655,414,612

Number and value of farm animals in the United States for the years 1868 to 1896.

January 1—	Horses.		Mules.		Milch cows.	
	Number.	Value.	Number.	Value.	Number.	Value.
1868	5,756,940	$432,696,226	855,685	$66,415,769	8,691,568	$319,681,153
1869	6,332,793	533,021,787	921,662	98,386,359	9,247,714	361,752,676
1870	8,248,800	671,319,461	1,179,500	128,584,796	10,095,600	394,940,745
1871	8,702,000	683,257,587	1,242,300	126,127,786	10,023,000	374,179,093
1872	8,990,900	659,707,916	1,276,300	121,027,316	10,303,500	329,408,983
1873	9,222,470	684,463,957	1,310,000	124,658,085	10,575,900	314,358,931
1874	9,333,800	666,927,406	1,339,350	119,501,859	10,705,300	299,609,309
1875	9,504,200	646,370,939	1,393,750	111,502,713	10,906,800	311,089,824
1876	9,735,300	632,446,985	1,414,500	106,565,114	11,085,400	320,346,728
1877	10,155,400	610,206,631	1,443,500	99,480,976	11,260,800	307,743,211
1878	10,329,700	600,813,681	1,637,500	104,323,939	11,300,100	298,499,866
1879	10,938,700	573,254,808	1,713,100	96,033,971	11,826,400	256,953,928
1880	11,201,800	613,296,611	1,729,500	105,948,319	12,027,000	279,899,420
1881	11,429,626	667,954,325	1,720,731	120,096,164	12,368,653	296,277,060
1882	10,521,554	615,824,914	1,835,169	130,945,378	12,611,632	326,489,310
1883	10,838,110	765,041,308	1,871,079	148,732,390	13,125,685	396,575,405
1884	11,169,683	833,734,400	1,914,126	161,214,976	13,501,206	423,486,649
1885	11,564,572	852,282,947	1,972,569	162,497,097	13,904,722	412,903,093
1886	12,077,657	860,823,208	2,052,593	163,381,096	14,235,388	389,985,523
1887	12,496,744	901,685,755	2,117,141	167,057,538	14,522,083	378,789,589
1888	13,172,936	946,096,154	2,191,727	174,853,563	14,856,414	366,252,173
1889	13,663,294	982,194,827	2,257,574	179,444,481	15,298,625	366,226,376
1890	14,213,837	978,516,562	2,331,027	182,394,099	15,952,883	353,152,133
1891	14,056,750	941,823,222	2,296,532	178,847,370	16,019,591	346,397,900
1892	15,498,140	1,007,593,636	2,314,699	174,882,070	16,416,351	351,378,132
1893	16,206,802	992,225,185	2,331,128	164,763,751	16,424,087	357,299,785
1894	16,081,139	769,224,799	2,352,231	146,232,811	16,487,400	358,998,661
1895	15,893,318	576,730,580	2,333,108	110,927,834	16,504,629	362,601,729
1896	15,124,057	500,140,186	2,278,946	103,204,457	16,137,586	363,955,545
1897	14,364,667	452,649,396	2,215,654	92,302,090	15,941,727	369,239,993

January 1—	Oxen and other cattle.		Sheep.		Swine.		Total value of farm animals.
	Number.	Value.	Number.	Value.	Number.	Value.	
1868	11,942,484	$249,144,599	38,991,912	$98,407,809	24,317,258	$110,766,266	$1,277,111,822
1869	12,185,385	306,211,473	37,724,279	82,139,979	23,316,476	146,188,755	1,527,704,029
1870	15,388,500	346,926,440	40,853,000	93,364,433	26,751,400	187,191,502	1,822,327,377
1871	16,212,200	369,940,056	31,851,000	74,035,837	29,457,500	182,602,352	1,810,142,711
1872	16,389,800	321,562,693	31,679,300	88,771,197	31,796,300	138,733,828	1,659,211,933
1873	16,413,800	329,298,755	33,002,400	97,922,350	32,632,050	133,729,615	1,684,431,693
1874	16,218,100	310,649,803	33,928,200	88,690,569	30,860,900	134,565,526	1,619,944,472
1875	16,313,400	304,858,859	33,783,600	94,320,652	28,062,200	149,869,234	1,618,012,221
1876	16,785,300	319,623,509	35,935,300	93,666,318	25,726,800	175,070,484	1,647,719,138
1877	17,956,100	307,105,386	35,804,200	80,892,683	28,077,100	171,077,196	1,576,506,083
1878	19,223,300	329,541,703	35,740,500	80,603,062	32,262,500	160,838,532	1,574,620,783
1879	21,408,100	329,543,327	38,123,800	79,023,984	34,766,100	110,613,044	1,445,423,062
1880	21,231,000	341,761,154	40,765,900	90,230,537	34,034,100	145,781,515	1,576,917,556
1881	20,938,710	362,861,509	43,569,899	104,070,759	36,247,683	170,535,435	1,721,795,252
1882	23,280,238	463,069,501	45,016,224	105,595,954	44,122,200	263,543,195	1,906,468,252
1883	28,046,077	611,549,109	49,237,291	124,366,335	43,270,086	291,951,231	2,338,215,768
1884	29,046,101	683,229,054	50,626,626	119,902,706	44,200,893	246,301,139	2,467,868,924
1885	29,866,573	694,382,913	50,360,243	107,960,650	45,142,657	226,401,683	2,456,428,383
1886	31,275,242	661,956,274	48,322,331	92,443,867	46,092,043	196,569,894	2,365,159,862
1887	33,511,750	663,137,926	44,759,314	89,872,839	44,612,836	200,043,291	2,400,586,938
1888	34,378,363	611,750,520	44,544,755	89,279,926	44,346,525	220,811,082	2,409,043,418
1889	35,032,417	597,236,812	42,599,079	90,640,369	50,301,592	291,307,193	2,507,050,058
1890	36,849,024	560,625,137	44,336,072	100,659,761	51,602,780	243,418,336	2,418,766,028
1891	36,875,648	544,127,908	43,421,136	108,397,447	50,625,106	210,193,923	2,329,787,770
1892	37,651,239	570,749,155	44,938,365	116,121,290	52,398,019	241,031,415	2,461,755,698
1893	35,954,196	547,882,204	47,273,553	125,909,264	46,094,807	295,426,492	2,483,506,681
1894	36,608,168	536,789,747	45,048,017	89,186,110	45,206,498	270,384,626	2,170,816,754
1895	34,364,216	482,999,129	42,294,064	66,685,767	44,165,716	219,501,267	1,819,446,306
1896	32,085,409	508,928,416	38,298,783	65,167,735	42,842,759	186,529,745	1,727,926,084
1897	30,508,408	507,929,421	36,818,643	67,020,942	40,600,276	166,272,770	1,655,414,612

Prices of principal agricultural products on the farm December 1, 1892 to 1896.

State or Territory.	Corn (per bushel).					Wheat (per bushel).					Oats (per bushel).				
	1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1896.
	Cts	Cts	Cts	Cts	Cts						Cts	Cts	Cts	Cts	Cts
Maine	67	62	72	54	47	$1.02	$1.02	$0.79	$0.82	$0.84	45	45	44	31	31
New Hampshire	65	57	76	51	45	1.00	.85	.80	.76	1.00	44	43	49	35	35
Vermont	61	61	69	48	38	.96	.85	.67	.69	.93	43	42	51	33	31
Massachusetts	62	62	61	52	46	.97	----	----	----	----	48	42	43	34	35
Rhode Island	63	69	75	56	49	----	----	----	----	----	49	43	47	39	31
Connecticut	62	64	68	51	42	.87	----	----	.68	----	45	40	43	31	31
New York	60	55	61	45	38	.85	.76	.62	.68	.88	39	30	39	28	26
New Jersey	58	52	54	42	36	.83	.70	.61	.71	.89	41	35	58	25	28
Pennsylvania	57	49	55	39	33	.81	.65	.56	.65	.83	40	35	35	27	24
Delaware	44	40	45	34	25	.75	.60	.55	.64	.87	38	38	35	29	21
Maryland	45	44	50	37	32	.74	.76	.54	.64	.88	38	35	29	27	23
Virginia	53	46	47	37	32	.76	.63	.56	.65	.80	39	35	37	30	26
North Carolina	54	50	47	38	37	.89	.72	.65	.72	.83	45	44	44	38	35
South Carolina	57	60	65	46	46	.93	.98	.87	.88	.89	52	53	53	49	48
Georgia	56	56	58	41	43	.90	.90	.76	.82	.89	52	52	51	46	41
Florida	60	68	71	47	53	----	----	----	----	----	55	55	61	65	53
Alabama	52	59	53	37	45	.93	.88	.78	.80	.85	51	51	51	42	41
Mississippi	51	55	49	37	41	.90	.85	.75	.61	.82	50	47	47	39	41
Louisiana	50	57	62	40	45	----	----	----	----	----	50	41	47	36	34
Texas	45	54	56	31	41	.75	.58	.54	.66	.75	38	42	39	26	34
Arkansas	47	45	47	32	37	.86	.65	.55	.59	.71	40	39	40	32	31
Tennessee	43	39	39	27	28	.68	.57	.51	.62	.74	38	31	35	27	26
West Virginia	56	55	57	40	34	.75	.72	.60	.69	.78	41	38	39	32	28
Kentucky	40	43	44	27	25	.67	.57	.50	.61	.76	37	34	36	25	21
Ohio	42	40	43	27	21	.68	.57	.49	.60	.78	35	30	31	22	17
Michigan	46	45	50	32	21	.67	.57	.52	.60	.84	35	32	31	24	19
Indiana	40	36	37	23	19	.64	.53	.46	.57	.80	34	28	30	20	15
Illinois	37	31	39	22	18	.63	.51	.45	.53	.74	31	27	29	17	15
Wisconsin	38	35	45	30	22	.62	.54	.51	.51	.70	29	27	30	18	17
Minnesota	37	34	43	20	19	.61	.51	.49	.44	.68	28	26	30	14	15
Iowa	32	27	45	18	14	.60	.49	.50	.46	.62	26	23	28	14	12
Missouri	36	30	40	20	26	.58	.48	.43	.51	.70	30	25	29	18	17
Kansas	31	31	43	19	18	.52	.42	.44	.45	.63	26	27	31	17	16
Nebraska	28	27	50	18	13	.50	.40	.49	.40	.58	23	22	36	11	11
South Dakota	33	25	46	23	18	.51	.44	.46	.38	.62	23	25	35	17	13
North Dakota	40	38	44	24	25	.52	.43	.43	.38	.64	28	28	29	16	18
Montana	70	70	82	75	60	.69	.60	.54	.73	.66	40	37	31	44	31
Wyoming	61	63	65	57	78	.66	.65	.63	.64	.62	38	40	48	39	53
Colorado	40	51	61	41	36	.58	.52	.65	.56	.61	34	37	46	23	30
New Mexico	72	71	75	56	55	.80	.75	.78	.73	.66	56	51	50	45	40
Arizona	67	66	100	75	----	.78	.65	1.00	.65	.80	----	----	----	----	----
Utah	58	58	58	49	51	.62	.60	.57	.44	.68	40	33	31	30	39
Nevada	----	----	----	----	----	.75	.73	.75	.49	.69	----	----	----	----	----

State or Territory.	Barley (per bushel).					Hay (per ton).					Cotton (per pound).				
	1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1896.
	Cts	Cts	Cts	Cts	Cts						Cts	Cts	Cts	Cts	Cts
Maine	68	67	66	52	43	$12.80	$12.13	$9.60	$9.68	$10.25	----	----	----	----	----
New Hampshire	74	70	63	56	53	13.20	15.60	10.50	12.50	12.90	----	----	----	----	----
Vermont	66	60	60	47	41	10.00	10.63	9.94	12.25	10.28	----	----	----	----	----
Massachusetts	75	90	63	65	58	16.60	17.33	15.50	17.50	16.40	----	----	----	----	----
Rhode Island	82	87	72	75	60	17.40	19.60	16.33	17.25	16.60	----	----	----	----	----
Connecticut	76	----	----	----	----	16.50	17.50	15.56	15.10	14.71	----	----	----	----	----
New York	75	60	56	81	39	11.00	11.33	9.66	13.70	12.04	----	----	----	----	----
New Jersey	----	----	----	----	----	14.25	17.43	14.09	12.64	14.35	----	----	----	----	----
Pennsylvania	57	50	48	41	40	12.30	14.40	11.31	12.30	12.15	----	----	----	----	----
Delaware	----	----	----	----	----	12.33	17.00	15.00	12.16	13.00	----	----	----	----	----
Maryland	----	55	----	----	----	11.75	11.25	11.13	11.55	11.85	----	----	----	----	----
Virginia	----	48	----	----	----	11.50	13.09	11.89	11.43	10.21	8.6	7.1	5	7.8	7.1
North Carolina	----	52	----	----	----	10.55	11.13	10.93	10.14	10.75	8.0	7.2	4.8	8.2	6.7
South Carolina	----	115	----	----	----	11.30	9.67	10.75	7.62	11.32	8.6	7.1	5	8.8	6.8
Georgia	----	115	----	----	----	11.80	12.06	12.39	10.90	11.05	8.5	7.3	4.5	7	7.0
Florida	----	----	----	----	----	14.00	10.75	16.25	13.23	13.00	8.2	7.3	4.8	11.5	8.7
Alabama	----	----	----	----	----	10.80	11.24	9.51	10.21	9.80	8.5	7	4.8	7.8	6.5
Mississippi	----	----	----	----	----	9.91	9.61	9.67	9.70	9.46	8.5	7	4.1	7.5	6.7
Louisiana	----	----	----	----	----	9.80	9.00	10.61	9.64	8.75	8.4	7	4.3	7.8	6.7
Texas	65	62	55	54	50	8.56	9.60	7.62	6.43	7.20	8	6.9	4.5	7.3	6.5
Arkansas	----	----	----	----	----	8.74	9.37	8.83	9.27	7.54	8.5	6.8	4.8	7.6	6.4
Tennessee	66	55	56	50	45	10.40	10.76	11.27	10.83	9.67	8.5	6.5	4.5	7.3	6.2
West Virginia	----	----	----	38	----	10.50	12.75	10.66	12.73	9.79	----	----	----	----	----
Kentucky	38	51	47	38	40	9.50	10.16	10.47	10.94	9.46	----	----	----	----	----
Ohio	57	47	48	41	38	9.17	10.65	8.46	12.76	7.93	----	----	----	----	----
Michigan	60	49	50	43	42	8.40	9.16	9.64	13.09	8.48	----	----	----	----	----
Indiana	52	45	45	40	33	7.80	9.16	7.58	12.03	7.18	----	----	----	----	----
Illinois	49	40	48	45	31	7.53	8.86	8.33	10.25	6.39	----	----	----	----	----
Wisconsin	50	43	45	34	27	7.65	7.20	7.96	9.63	6.60	----	----	----	----	----
Minnesota	42	36	41	24	20	4.69	4.57	5.30	5.12	3.79	----	----	----	----	----
Iowa	40	33	42	23	21	5.25	6.16	7.39	6.45	3.99	----	----	----	----	----
Missouri	42	40	51	48	25	6.75	7.04	7.82	6.80	4.85	7.8	----	4.6	7.4	6.2
Kansas	35	47	49	23	22	4.40	4.69	5.25	3.26	2.70	----	----	----	----	----
Nebraska	34	31	43	24	19	4.27	4.87	7.12	3.56	2.44	----	----	----	----	----
South Dakota	35	33	35	19	19	2.40	3.67	4.28	3.29	3.12	----	----	----	----	----
North Dakota	33	31	36	20	21	4.10	3.72	3.87	3.48	3.39	----	----	----	----	----
Montana	66	59	40	59	57	8.95	7.89	7.17	1.40	6.86	----	----	----	----	----
Wyoming	68	73	----	28	----	6.40	8.00	10.00	6.50	7.14	----	----	----	----	----
Colorado	51	50	58	60	46	6.50	6.98	7.51	5.87	6.22	----	----	----	----	----
New Mexico	65	58	70	68	65	11.25	8.50	11.50	8.00	5.70	----	----	----	----	----
Arizona	----	52	75	70	----	10.50	8.25	12.05	9.00	8.75	----	----	----	----	----
Utah	52	45	46	39	42	6.51	5.17	5.56	5.27	5.09	----	----	----	----	----
Nevada	60	60	51	50	----	7.06	10.00	7.25	6.75	4.82	----	----	----	----	----

Idaho	70	71	59	62	----	.60	.60	.46	.47	.65	37	41	32	29	30	33	53	47	42	22	7.40	5.50	4.34	6.25	4.71	----	----	----	----	----
Washington	60	62	69	40	57	.58	.48	.39	.41	.74	35	35	31	28	40	45	39	32	38	40	9.00	9.17	7.38	6.75	7.09	----	----	----	----	----
Oregon	56	47	56	55	56	.64	.55	.43	.47	.72	37	37	28	27	33	46	40	33	40	45	8.92	8.10	5.86	6.12	6.60	----	----	----	----	----
California	55	50	57	53	53	.68	.53	.57	.60	.83	40	38	44	39	44	47	42	45	40	48	8.76	7.87	9.50	7.06	6.35	----	----	----	----	----
Oklahoma	----	----	----	----	----	------	------	.51	.48	.68	----	----	----	----	----	----	----	----	----	----	------	------	------	------	------	----	----	----	----	----
Indian Territory	----	----	----	----	----	------	------	------	------	------	----	----	----	----	----	----	----	----	----	----	------	------	------	------	------	----	----	4.6	7.5 7.3	6.2
General average	39.3	36.5	45.7	25.3	21.5	.624	.538	.491	.509	.726	31.7	29.4	32.4	19.9	18.7	47.2	41.1	44.2	33.7	32.3	8.49	8.68	8.54	8.35	6.55	8.4	6.99	4.6	7.59	6.6

Wholesale prices of principal agricultural products in leading cities of the United States, 1892 to 1896.

CORN (PER BUSHEL).

Date.	Boston.		New York.		Richmond.		New Orleans.		Cincinnati.		Chicago.		Kansas City.		St. Paul.		St. Louis.		San Francisco (per cental).	
1892.	*Steamer mixed*		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2.*		*No. 2 mixed.*		*No. 3 yellow.*		*No. 2.*		*No. 1 white.*	
August	$0.59 to	$0.59½	$0.59 to	$0.60	$0.57 to	$0.58	$0.63 to	$0.64	$0.53 to	$0.53½	$0.49⅜ to	$0.49⅝		$0.43½	$0.45 to	$0.47	$0.45⅛ to	$0.45⅝	$1.40 to	$1.42½
September		.61		.58¼	.57	.58		.60	.50	.51	.48½	.48¾		.42½	.47	.48	.44	.44½	1.37½	1.40
October		.55½	.51⅞	.52¼	.55	.56	.59	.60	.46½	.47	.43⅜	.43⅝		.37½	.44	.45	.40⅝	.41	1.35	1.36¼
November	.52¼	.53	.50⅛	.51⅛	Nominal.		.52	.53		.43	.41⅜	.41⅝		.33	.40	.41		.38½	1.15	1.17½
December	.54	.55	.51¼	.51⅞	.49	.50		.51		.43	.42	.42½		.38½	.39	.40	.38¼	.38⅝	1.12½	1.15
1893.																				
August		.49	.46⅛	.46¼	.47	.48		.51		.41	.38	.38⅜		.28¼	.35	.36	.34¼	.34⅝	1.00	1.02½
September		.50	.45	.45½		.47		.50		.41½	.37½	.37¾		.30½	.35	.36	.34	.34½	.90	.95
October		.51		.49	.50	.51		.53	.42½	.43	.39¾	.40⅛		.34	.37	.38	.35⅝	.36	.92½	.96
November		.50	.45⅛	.46⅛		.47	.51	.52		.39	.38¼	.38½	$0.31½ to	.32	.37	.38		.35⅜	.85	.87½
December		.46½	.44⅛	.45¼	.43	.44		.49		.40	.34⅞	.35⅛	.30	.30¼	.33	.34		.34	.90	.92½
1894.																				
August		.57	.53½	.54	.52	.53	.56	.57		.50	.46⅛	.46¾	.41	.42	.45½	.46½	.44½	.45½	1.35	1.37½
September		.65½			.61	.62		.70		.56	.53¾	.57¾		.52½	.57	.58	.53½	.54	1.25	1.27½
October		.60	.55½	.55½		.59		.71	.54½	.54¾	.49⅜	.49⅝		.46	.54	.54½	.49¼	.50¼	1.30	1.32½
November		.61½		.60		.55		.57		.52½	.52	.52¾	.42½	.43	.54½	.55	.48⅝	.48½	1.30	1.32½
December		.54		.58	.43	.44	.53	.54		.46	.46¾	.47	.41⅛	.41¾	.51	.52	.45⅛	.45¼	1.27½	1.30
1895.															*No. 3.*					
August		.54	.48⅛	.49½		.49	.53	.54		.43¼	.43	.44½			.42½	.43		.39	1.07½	1.10
September	.45	.46	.40⅜	.41¾		.41		.45	.37	.37½	.35⅞	.36⅜		.30	.35½	.36½	.33	.33⅛		
October	.41½	.42	.37	.37⅝		.39		.38		.33½	.30¾	.31¼	.26½	.26¼	.31½	.32		.26½		
November	.39	.39½		.37⅛		.36		.39		.32	.29⅜	.29¾		.23½	.30	.30½		.26½		
December		.38		.35		.36		.37		.30	.26⅛	.26⅜	.22½	.23	.24	.24½		.24½		
1896.																				
August		.33½	.30⅝	.31	.31	.31½	.32	.33		.26½	.24⅛	.24⅞	.21⅝	.22	.23½	.24		.22¼	.80	.82½
September	.29½	.30	.25¾	.26⅛		.28	.28	.29	.24½	.25	.20¼	.20¾	.18	.18½	.19	.20	.18¼	.18½	.77½	.80
October		.31	.28	.29¼	.28	.29	.28	.29		.25½	.22⅝	.23⅝	.20¼	.20½	.20	.21		.21½		
November		.34	.31	.31¼	.31	.31½	.35	.36		.26	.24	.24⅛	.19	.21	.23	.23½		.22¾		
December		.30	.28⅞	.29⅛	.27½	.28	.34	.35	.22	.22½	.23	.23½	.18½	.19	.24½	.25		.21½		

Wholesale prices of principal agricultural products in leading cities of the United States, 1892 to 1896—Continued.

WHEAT (PER BUSHEL).

Date.	Boston.	New York.		Richmond.		New Orleans.	Cincinnati.		Chicago.		Kansas City.		St. Paul.		St. Louis.		San Francisco (per cental).	
1892.		*No. 2 red.*		*No. 2 red.*			*No. 2 red.*		*No. 2 red winter.*		*No. 2 hard.*		*No. 2 northern.*		*No. 2 red winter.*		*No. 1 white.*	
August	......	$0.83⅝ to	$0.84¾	$0.82½ to	$0.83	......		$0.75	$0.77½ to	$0.77¾		$0.65	$0.73 to	$0.75	$0.73¼ to	$0.73½	$1.37½ to	$1.38¾
September	......	.78⅝	.79⅝	.77	.78	......		.73		.73¾		.65	.68	.70	.68⅞	.69	1.28¾	1.30
October	......	.79¼	.79½	.78	.79	......	$0.72½ to	.73	.72¾	.73½		.61½	.66	.68		.69	1.28⅝	1.30
November	......	.74⅝	.75⅜	.72	.73	......		.66	.70¾	.71		.60	.63	.65	.65½	.65⅞	1.27½	1.30
December	......	.76⅝	.78⅛	.76	.77	......		.70	.71¼	.71¾		.65	.62	.65		.68¾	1.26¼	1.27½
1893.																		
August	......	.66⅝	.68½	.64	.64½	......	.52½	.53	.57½	.59½		.46½	.54	.55	.54½	.54⅞	1.07½	1.10
September	......	.69	.69¾	.63½	.64	......	.57	.58	.62¾	.63¼		.51½	.56	.57		.59½	1.01¼	1.02½
October	......	.72⅛	.72½	.70	.71	......		.64	.66	.66⅝		.55	.58	.59		.62⅝	1.04	1.05
November	......	.67¾	.68¼		.69	......		.59½	.62½	.62⅞	$0.50½ to	.51	.58	.59		.58¼	1.02½	1.05
December	......	.68⅛	.69¼		.64	......	.59	.60	.63	.63½	.53	.53½	.57	.58		.59⅜	1.02½	1.03¼
1894.																		
August	......	.55¼	.56½		.54	......	.48	.48½	.52	.53	.44	.45	.56½	.57		.47¾	.87½	.90
September	......	.57⅞	.58⅜	.57	.57½	......		.51	.53	.53¾	.53	.53½	.52	.54½	.49¾	.50⅞	.85	.86¼
October	......	.56	.57½		.55	......	.51⅜	.51½	.51⅝	.52		.54½	.53	.54	.48½	.48⅞	.77½	.78¾
November	......	.56½	.57	.56	.56½	......		.51	.52⅛	.53½	.47½	.48	.54½	.55	.48½	.48⅞	.85	.86¼
December	......	.60⅝	.61⅛		.60	......		.53	.55⅛	.56	.53	.54	.57½	.58½	.52¼	.52⅜	.92½	.93¾
1895.																		
August	......	.75	.75½		.72	......		.71	.67⅝	.69¼		.68½	.67	.67½		.68½	.96	.97½
September	......	.65⅛	.67		.67	......		.64	.60	.61¾		.60	.55¼	.56	.61¼	.61¾	......	
October	......	.66¾	.69⅞		.72	......		.79	.61⅛	.61½		.64	.55	.55½		.64½	......	
November	......	.70½	.71⅝	.72	.73	......		.66½	.58⅝	.62⅞		.58	.53½	.54		.61¼	......	
December	......	.70⅞	.71½		.71	......		.67½	.59¼	.61½	.57½	.58	.53	.54		.63	......	
1896.																		
August	......	.68⅛	.68¾		.64½	......		.62	.61½	.62		.53	.55	.56	.59	.59½	.95	.97½
September	......	.66¾	.67½	.64	.64½	......		.61	.60	.60½		.51	.53	.53½	.58½	.58¾	.95	.97½
October	......	.79⅝	.80¾	.72	.72½	......	.74	.75	.70¼	.72		.65	.64¼	.65	.68½	.69	......	
November	......	.86¾	.88⅛	.79	.80	......	.81½	.82	.77½	.78		.65	.69	.70	.76	.77	......	
December	......	1.01	1.02½	.95	.96	......		.97	.90¼	.92⅝	.82	.83	.80½	.81½	.91	.92	......	

OATS (PER BUSHEL).

	No. 2 white.		*No. 2 mixed.*		*No. 2 mixed.*		*No. 2.*		*No. 2 mixed.*		*No. 2.*		*No. 2 mixed.*		*No. 2 white.*		*No. 2.*		*No. 1.*	
1892.																				
August	$0.41 to	$0.41½	$0.35½ to	$0.36	$0.38 to	$0.38½		$0.40	$0.33 to	$0.33½	$0.30½ to	$0.30⅝		$0.26	$0.31½ to	$0.32		$0.30	$1.37½ to	$1.40
September		.42	.37	.38	.37	.38	$0.40 to	.41	.34	.34¼	.33⅛	.33⅞		.27¼	.32	.32½		.29⅝	1.32½	1.35
October	.40½	.41		.36	.37	.38		.40	.33¼	.35½	.31	.31¼		.26½	.32	.33	$0.29⅝ to	.29⅞	1.25	1.27½
November		.41½		.35¾	.35½	.36		.38	.32	.32½		.30	----	----	.29½	.30½	.28⅝	.29	1.25	1.27½
December		.43		.36½	.39	.40		.41	.35½	.36		.31½		.32	.31½	.32		.31	1.27½	1.30
1893.																				
August		.39	.35½	.36	.32	.33	.38	.38½	.21	.22	.23	.23⅝		.23	.29½	.30½		.22½	1.05	1.10
September	.35	.35½	.30½	.30¼	.31	.32		.34	.26¼	.26½	.23¾	.21	$0.27 to	.29	.26¼	.27½	.23¼	.23½	1.07½	1.10
October	.37	.37½	.34½	.34¾	.34	.35		.36	.31	.32	.27¾	.28		.28½	.26½	.27½		.27¼	1.10	1.12½
November		.37½	.34½	.34¾	.34½	.35		.38		.29½		.28	.26½	.27½	.27½	.28		.26¾	1.05	1.10
December		.38	.34⅝	.34½	.34½	.35		.38	.31½	.32		.28¾	.27	.27½	.27	.27½		.27¾	1.05	1.07½
1894.																				
August	.44	.45		.40		.34½	.38	.39	.30½	.31	.28¾	.29	.27½	.28	----	----		.28⅝	1.12½	1.15
September	.38	.38½	.33¾	.34	.34	.34½	.38½	.39		.31	.29½	.30¼		.31	.32	.32½		.30¼	1.02½	1.05
October	.37	.37½	.32½	.32¾	.33	.34		.38		.31¼	.28¼	.28½	.28½	.29¼	.31½	.32	.28⅝	.29½	1.00	1.02½
November	.37½	.38	.32½	.32¾	.32½	.33		.38		.30½	.28¾	.29	.29	.30	.30½	.31		.29½	.95	.97½
December		.40	.33⅝	.33¾	.34	.35	.38	.38½	.31½	.32½	.29½	.29½	.30½	.31	.31	.31½		.30	.95	.97½
1895.																			*No. 1 feed.*	
August	.33	.33½		.28	.28½	.29		.32	.25	.27	.22½	.22⅞		.19		.25		.24	.87½	.90
September	.27½	.28		.24	.24	.24½		.28	.21¾	.22	.19	.20¾		.17½		.25½	----	----	----	----
October	.27½	.28	.24	.24½	.24½	.25	.27½	.28	.21	.21½	.18⅝	.18¾	.18	.19	----	----	----	----	----	----
November	.26	.27		.24	.23	.23½		.27	.20	.20¾		.18	.15	.16	----	----		.17⅝	----	----
December		.25½	.22¾	.22⅞	.23	.23½		.26	.21½	.21¾		.17¾		.18½	----	----		.18	----	----
1896.															*No. 3 white.*					
August		.27		.23	.23	.23½		.25½		.21½		.18½		.20	.17½	.17¾		.19	.80	.85
September		.26		.20	.20½	.21		.26		.17½	.15⅝	.16		.17	.17	.17½		.17	.87½	.90
October		.25½		.22	.19	.19½		.25		.18	.18	.18⅜		.15	.18½	.19		.16	----	----
November	.26	.26½	.22½	.23	.20	.20½	.25	.26	.19	.19½	.18½	.18½		.16	.17	.17½	.16¾	.17	----	----
December		.26½	.23¼	.23¾	.21½	.22	.25	.25½	.19½	.20		.18¼	.17½	.18	.18	.18½		.19	----	----

Wholesale prices of principal agricultural products in leading cities of the United States, 1892 to 1896—Continued.

BARLEY (PER BUSHEL).

Date.	Boston.	New York.	Richmond.	New Orleans.	Cincinnati.	Chicago.	Kansas City.	St. Paul.	St. Louis.	San Francisco (per cental).
1892.	*Two-rowed State.*	*Two-rowed State.*			*No. 2 spring.*	*Fair to choice.*		*No. 2.*	*Choice.*	*No. 1 Chevalier.*
August					$0.64 to $0.68	$0.45 to $0.63				
September					.65	.43 .65		Nominal.		
October		$0.65			.65 .68	.58 .68		$0.48 to $0.50	$0.65	$1.15½ to $1.17½
November		$0.63 to .68			.65 .67	.48 .55		.48 .50	.60	1.12½ 1.15
December		.65 .68			.65 .67	.50 .58		.50 .55	$0.62 to .63	1.12 1.15
1893.										
August					.60 .65	.30 .35		.50 .55		
								Sample.		
September					.50 .52	.45 .52		.30 .45		1.17½ 1.20
October		.55 .60			.56 .58	.46 .58		.35 .48	.55 .58	1.15 1.17½
November		.60 .65			.58 .60	.40 .54		.35 .43	.57	1.15 1.17½
December	$0.60 to $0.65	.63 .64			.58 .60	.46 .52		.35 .48	.57	1.15 1.17½
1894.	*Six-rowed western.*	*No. 2 Milwaukee.*						*No. 2 round.*		
August					.57 .60					1.25 1.27½
September	.68 .73					.55 .57½		.45 .50	.60	1.25 1.27½
October	.68 .73	.61 .62			.62 .63	.52 .54½		.45 .50	.55 .57	1.25 1.27½
November	.65 .70	.61 .62			.60 .62	.53 .56		.45 .50	.55 .56	
December	Nominal.	.63 .64			.60 .62	.52 .54½		.46 .50	.55	
1895.	*Western.*					*No. 3.*		*No. 3.*	*Choice.*	
August	Nominal.				.60 .62	.37		.40 .45		1.07 1.10
September	Nominal.					.36 .42		.32 .33		
October	.45 .55					.25 .37		.32 .34	.40	
November	.45 .55				.40 .45	.28 .40		.32 .35	.35 .37	
December	.45 .50				.39 .44	.28 .40		.28 .30	.34 .36	
1896.								*No. 4.*		
August	Nominal.	Out of season.			.45	.28 .30		.21 .24	Out of season.	.97½ 1.00
September	Nominal.	Out of season.			.45	.25 .32		.21 .24	Out of season.	.95 .97½
October	Nominal.	Out of season.			.45	.32 .36		.24 .26	.35	
November	Nominal.	Nominal.			.40 .42	.24 .38		.22 .23	.37	
December	Nominal.	.47				.25 .37		.21 .26	.36	

HAY (PER TON).

	Fair to good.		Prime timothy.		No. 1 timothy.		Choice.		No. 1 timothy.		No. 1 timothy.			Timothy.		Timothy (fancy).		No. 1 barley.	
1892.																			
August	$17.00 to	$18.00		$19.00		$15.00	$16.50 to	$17.50	$11.50 to	$12.00	$12.00 to	$12.50	......	$9.00 to	$10.00		$13.00	$9.00 to	$10.00
September	17.00	18.00		17.00	$15.00 to	15.25	16.50	17.50	10.00	10.50	10.50	11.50	......	9.00	10.00		12.00	7.50	8.50
October	16.50	17.00	$17.00 to	18.00	14.00	14.50	16.50	17.50	11.00	11.50	10.50	11.00	......	9.00	10.00		13.00		7.50
November	16.00	17.00		17.00	13.50	14.00	15.50	16.00	10.00	10.50	10.50	11.00	......	8.00	9.50		11.50	8.00	9.00
December	16.00	17.00		18.00	15.50	16.00	15.50	16.00	10.50	11.00	11.00	12.00	......	8.00	9.50		12.50	8.00	9.00
1893.																			
August	17.00	18.00		20.00	17.00	17.50	18.00	18.50		13.50	9.50	10.50	......	6.00	8.00		15.00	7.00	9.00
September	17.00	18.00	17.00	18.00	15.00	15.50	16.50	17.50	12.00	13.00	10.00	10.50	......	7.50	9.00		11.50	8.50	9.00
October	16.00	17.00	17.00	18.00	15.00	15.50	16.00	16.50		12.50	10.00	11.00	......	7.00	8.50		12.50	8.50	9.00
November	15.00	16.00	17.00	18.00	14.50	15.50	17.00	18.00	11.50	12.00	10.50	11.00	......	7.50	8.50		12.00	10.00	11.00
December	15.00	16.50		17.00	14.00	14.50	16.50	17.00	11.00	12.00	10.00	10.50	......	7.50	8.50		12.50	10.00	11.00
1894.																			
August	15.00	15.50		18.00	13.00	13.50		17.00	11.00	11.50	11.00	12.00	......	......	......		12.00	9.00	10.00
September	15.00	15.50	15.00	16.00	13.50	14.00	15.50	16.50	10.00	10.50	9.50	10.00	......	9.00	10.00		12.00	8.00	9.00
October	13.00	13.50		15.00	12.00	12.50	16.00	16.50	9.50	10.00	10.00	10.50	......	9.50	10.50		11.50	9.00	10.00
November	13.00	13.50		15.00	12.50	13.00	16.00	16.50	9.00	9.50	10.00	10.50	......	9.50	10.50		12.00	9.00	10.00
December	13.00	13.50		15.00	12.50	13.00	16.00	17.00	10.00	10.50	10.00	11.00	......	10.00	11.00		12.00	9.00	10.00
1895.														*Wild.*					
August	16.00	17.00		21.00	16.00	17.00	20.00	21.00	16.50	17.00	12.00	13.00	......	7.00	8.50		16.00	6.00	7.00
September	16.00	17.00		19.00	14.00	16.00	20.00	21.00	13.50	14.00	11.50	12.50	......	6.00	8.00		14.00	......	......
October	16.00	17.00		17.00	15.50	16.50	19.00	20.00	13.50	14.00	11.50	12.50	......	7.00	8.50		13.00	......	......
November	16.00	17.00		18.00	16.50	17.00	19.00	20.00	13.75	14.75	11.50	12.00	......	7.50	8.75		13.00	......	......
December	17.00	18.00		18.00	16.50	17.00		22.00	14.00	14.75	12.00	13.00	......	6.50	8.25		15.00	......	......
1896.			*Per cwt.*																
August	16.00	17.00	0.95	1.00	14.00	15.00	16.50	17.00	13.00	13.50	8.00	8.50	......	5.00	6.50	$12.50 to	13.00	7.00	8.00
September	16.00	17.00	.90	.92½	11.50	12.50	16.00		9.00	9.50	7.58	8.00	......	6.00	6.50	9.00		7.00	8.00
October	14.00	15.00	.77½	.80	10.00	12.00	15.00		10.00	10.50	8.00	8.50	......	6.00	6.50		11.25	......	......
November		15.00	.85		11.00	12.50	16.00	16.50	9.50	10.00	8.50	9.00	......	5.50	6.50	10.00	10.50	......	......
December	15.00		.80	.82½	11.00	13.00	15.50	16.50	10.00	10.50	9.00	9.50	......	6.00	6.75		11.50	......	......

Wholesale prices of principal agricultural products in leading cities of the United States, 1892 to 1896—Continued.

COTTON (PER POUND).

Date.	Mobile.	New York.	Savannah.	New Orleans.	Cincinnati.	Memphis.	Charleston.		Norfolk.	St. Louis.	Vicksburg.
1892.	*Middling.*	*Middling.*	*Middling.*	*Middling.*	*Middling.*	*Middling.*	*Middling.*		*Middling.*	*Middling.*	*Middling.*
August	$0.07 3/16	$0.07½	$0.07 3/16	$0.07 3/16	$0.07⅝	$0.07¼		$0.07½	$0.07 3/16	$0.07 3/16	$0.06⅞
September	.07	.07½	.06¾	.07	.07⅝	.07		.06⅞	.07	.07	.06¾
October	.07 5/16	.07 11/16	.07¼	.07 7/16	.07¾	.07 7/16		.07¼	.07 7/16	.07½	.07 3/16
November	.07 9/16	.08 5/16	.07½	.07 11/16	.08	.07 11/16	$0.07⅝ to	.07 11/16	.07⅞	.07¾	.07 7/16
December	.09½	.09¾	.09½	.09 9/16	.10	.09⅞		.09⅝	.09⅜	.10	.09 5/16
1893.											
August	.07⅝	.08	.07⅝	.07⅝	.08⅛	.07⅝		.07¾	.07¾	.07 9/16	.07½
September	.07⅛	.07 13/16	.07 1/16	.07 5/16	.07½	.07 5/16		.06⅞	.07¼	.07¼	.07 3/16
October	.07½	.08 1/16	.07 7/16	.07¾	.08¼	.07 11/16	.07 9/16	.07⅝	.07½	.07 13/16	.07⅝
November	.07½	.08 3/16	.07½	.07⅝	.08	.07⅝		.07⅝	.07¾	.07 11/16	.07½
December	.07⅜	.08 1/16	.07 7/16	.07 9/16	.07⅞	.07⅝		.07½	.07 9/16	.07 9/16	.07 7/16
1894.											
August	.06 9/16	.06 15/16	.06⅝	.06⅝	.07¼	.06¾		.06½	.06¾	.06⅞	.06½
September	.06 7/16	.06⅞	.06 5/16	.06 7/16	.07	.06⅝		.06¼	.06 11/16	.06¾	.06 3/16
October	.05 11/16	.06¼	.05 9/16	.05 9/16	.06¼	.05⅝	.05½	.05⅝	.05⅞	.05¾	.05 5/16
November	.05 1/16	.05¾	.05 3/16	.05 3/16	.05½	.05 3/16		.05⅜	.05¼	.05¼	.04 15/16
December	.05¼	.05 13/16	.05 3/16	.05 5/16	.05⅝	.05 5/16		.05⅛	.05¼	.05⅜	.05 1/16
1895.											
August	.06⅞	.07⅛	.06 11/16	.06 9/16	.07	.06¾		.06⅝	.07	.06 11/16	.06⅝
September	.07⅝	.08¼	.07½	.07 9/16	.07⅞	.07 11/16		.07½	.07⅞	.07⅝	.07 5/16
October	.08⅝	.09 1/16	.08½	.08⅜	.08⅞	.08¼	.08⅝	.08 7/16	.08⅝	.08¼	.08½
November	....	.09	.08 7/16	.08⅝	.09	.08⅜		.08⅝	....	.08⅝	.08⅜
December	....	.08 9/16	.08⅛	.08 3/16	.08⅜	.08¼		.08⅛	....	.08 5/16	.08 1/16
1896.											
August	....	.07 7/16	.06⅝	.06 13/16	.07	.06 13/16		.06⅝	.06¾	.06¾	.06 9/16
September	....	.08 3/16	.07⅛	.07⅝	.07¾	.07½	.07 1/16	.07⅜	.07½	.07½	.07⅜
October	....	.08⅜	.07½	.07⅝	.08	.07⅝		.07⅜	.07⅝	.07⅝	.07⅝
November	....	.08 3/16	.07 3/16	.07⅜	.07⅝	.07 5/16		.07⅛	.07⅜	.07 5/16	.07⅛
December	....	.07 11/16	.07	.07⅝	.07⅛	.07 3/16		.07	.07¼	.07¼	.07⅛

EXPORTS AND IMPORTS OF AGRICULTURAL PRODUCTS.

Exports of domestic agricultural products from the United States during the five years ending June 30, 1892 to 1896, inclusive.

Article.	1892.		1893.		1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Animals and their products:										
Animals, live—										
Cattle ......number..	394,607	$35,099,095	287,094	$26,032,428	359,278	$33,461,922	331,722	$30,603,796	372,461	$34,560,672
Hogs ......do....	31,963	364,081	27,375	397,162	1,553	14,753	7,130	72,424	21,049	227,297
Horses ......do....	3,226	611,188	2,967	718,607	5,246	1,108,995	13,984	2,209,298	25,126	3,530,703
Mules ......do....	1,965	238,591	1,634	210,278	2,063	240,961	2,515	186,452	5,918	406,161
Sheep ......do....	46,960	161,105	37,260	126,394	132,370	832,763	405,748	2,630,686	491,565	3,076,384
All other, including fowls......	......	24,161	......	43,116	......	53,247	......	51,389	......	39,752
Animal products—										
Beeswax ......pounds..	127,470	31,898	77,434	22,048	469,763	118,093	309,212	90,875	222,612	65,844
Bones, hoofs, horns and horn tips, strips, and waste	......	218,639	......	319,848	......	260,675	......	288,084	......	321,680
Casings for sausages	......	878,675	......	1,409,280	......	1,280,514	......	1,581,891	......	1,771,680
Dairy products—										
Butter ......pounds..	15,047,246	2,445,878	8,920,107	1,672,690	11,812,092	2,077,608	5,598,812	915,533	19,373,913	2,937,203
Cheese ......do....	82,100,221	7,677,657	81,350,923	7,624,648	73,852,134	7,180,331	60,448,421	5,497,539	36,777,291	3,091,914
Milk	......	236,358	......	274,155	......	322,288	......	219,785	......	270,453
Eggs ......dozen .	183,063	32,374	143,489	33,207	163,061	27,497	151,007	25,317	328,485	48,339
Egg yolks......	......	5,500	......	1,700	......	2,928	......	2,255	......	556
Feathers......	......	134,595	......	48,487	......	168,965	......	222,490	......	193,296
Glue ......pounds..	580,815	66,403	736,446	74,722	999,052	101,372	1,178,328	114,493	1,760,470	166,930
Grease, grease scraps, and all soap stock	......	1,298,598	......	1,067,723	......	1,380,299	......	904,071	......	1,516,763
Hair, and manufactures of	......	370,169	......	459,648	......	353,729	......	505,029	......	455,880
Hides and skins, other than furs ......pounds..	......	1,223,895	......	1,497,003	......	3,972,494	36,002,859	2,310,323	39,545,324	3,858,946
Honey	......	78,048	......	15,115	......	127,282	......	118,873	......	90,969
Meat products—										
Beef products—										
Beef, canned....pounds..	87,028,084	7,876,454	79,089,493	7,222,824	55,974,910	5,120,851	64,102,263	5,720,933	63,698,180	5,636,953
Beef, fresh ......do....	220,554,617	18,053,732	206,294,724	17,754,041	193,891,824	16,700,163	191,338,487	16,832,860	224,783,225	18,974,107
Beef, salted or pickled, pounds	70,204,736	3,987,829	58,423,963	3,185,321	62,682,667	3,572,054	62,473,325	3,558,230	70,709,209	3,975,113
Beef, other cured ...lbs..	953,712	92,524	898,920	87,776	1,218,334	100,631	821,673	73,569	514,303	59,371
Tallow ......do...	89,780,010	4,425,630	61,819,153	3,129,059	54,361,524	2,766,164	25,864,300	1,293,059	52,759,212	2,323,761
Mutton ......do..	101,463	9,022	108,214	9,175	2,197,900	174,404	591,449	47,832	422,950	31,793
Oleomargarine—										
Imitation butter....do...	1,610,837	195,587	3,479,322	416,386	3,898,950	475,003	10,100,897	992,468	6,063,699	587,269
The oil ......do...	91,581,703	9,011,889	113,939,363	11,207,250	123,295,895	11,942,842	78,098,878	7,107,014	103,276,756	8,087,905
Pork products—										
Bacon ......do...	507,919,830	39,334,933	391,758,175	35,781,470	416,657,577	38,338,843	452,549,976	37,776,293	425,352,187	33,442,847
Hams......do...	76,856,559	7,757,717	82,178,154	9,933,096	86,970,571	9,845,062	105,494,123	10,960,567	129,033,351	12,669,763
Pork, fresh......do...	377,746	30,246	912,644	79,317	1,168,647	92,095	818,581	66,660	741,656	43,739
Pork, pickled ......do. .	80,336,481	4,792,049	52,459,722	4,116,946	63,575,881	5,067,773	58,266,893	4,138,400	69,498,373	3,973,461
Lard ......do...	460,045,776	33,201,621	365,693,501	34,643,993	447,566,867	40,089,809	474,895,274	36,821,508	509,531,256	33,589,851

Exports of domestic agricultural products from the United States during the five years ending June 30, 1892 to 1896, inclusive—Continued.

Article.	1892.		1893.		1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Animals and their products—Continued										
Animal products—Continued.										
Meat products—Continued.										
Poultry and game		$13,828		$17,978		$18,633		$17,898		$40,647
All other meat products		1,220,205		1,245,466		1,386,089		1,600,231		1,767,437
Oils—										
Lard ... gallons	901,575	496,601	486,812	336,613	681,081	449,571	553,421	304,093	833,985	420,401
Other animal ... do	278,954	144,119	212,266	106,275	270,835	149,861	144,556	75,585	100,934	50,839
Quills		4,186		12,450		13,994		13,658		27,930
Rennets		(1)		780		1,320		1,801		815
Silk noils		(1)		3,140		(1)		(1)		1,958
Silk waste ... pounds	184,011	77,523	161,519	55,081	97,787	28,813	65,673	23,391	102,624	31,163
Silkworm eggs		7,410		6,500		683		2,850		25
Stearin ... pounds	1,350,512	66,470	293,423	14,669	321,898	17,938	36,429	2,157	668,585	34,289
Wool, raw ... do	202,456	30,664	91,858	14,808	520,247	90,676	4,279,109	484,463	6,945,981	855,950
Total value of animals and their products		182,027,147		171,428,673		189,529,928		176,460,118		183,264,812
Breadstuffs:										
Barley ... bushels	2,800,075	1,751,445	3,035,267	1,468,843	5,219,405	2,379,714	1,563,754	767,228	7,680,331	3,100,311
Bread and biscuits ... pounds	14,449,625	775,596	14,583,967	752,353	15,185,175	723,873	14,206,314	634,609	15,426,601	694,323
Corn (maize) ... bushels	75,451,849	41,590,460	46,037,274	24,587,511	65,324,841	30,211,154	27,691,137	14,650,767	99,992,835	37,836,862
Corn meal ... barrels	287,669	919,961	271,155	793,081	291,172	770,526	223,567	648,844	276,885	654,121
Oats ... bushels	9,425,078	3,842,559	2,380,643	951,920	5,750,268	2,027,934	569,977	200,793	13,012,590	3,497,611
Oatmeal ... pounds	20,908,190	555,957	5,762,701	160,660	9,719,337	238,528	20,439,253	566,321	38,592,504	939,502
Rye ... bushels	12,041,316	11,432,160	1,477,058	1,002,798	230,822	126,522	9,437	5,340	988,466	445,075
Rye flour ... barrels	4,552	22,461	2,811	10,290	3,055	9,273	3,768	12,082	3,777	11,163
Wheat ... bushels	157,280,351	161,399,132	117,121,109	93,534,970	88,415,230	59,407,041	76,102,704	43,805,663	60,650,080	39,709,868
Wheat flour ... barrels	15,196,769	75,362,283	16,620,339	75,494,347	16,859,533	69,271,770	15,268,892	51,651,928	14,620,864	52,025,217
All other, and preparations of, used as food		1,711,103		1,555,883		1,610,884		1,661,234		2,442,940
Total value of breadstuffs		299,363,117		200,312,654		166,777,229		114,604,780		141,356,993
Cotton and cotton-seed oil:										
Cotton—										
Sea island ... pounds	9,074,686	1,591,464	7,983,415	1,758,756	14,255,439	2,904,905	15,261,322	2,782,639	19,159,469	3,816,216
Other ... do	2,926,145,125	256,869,777	2,204,131,711	187,012,689	2,669,026,886	207,961,384	3,502,171,787	202,118,351	2,316,036,916	186,210,244
Cotton-seed oil ... gallons	13,859,278	4,982,285	9,462,074	3,927,556	14,958,309	6,008,405	21,187,728	6,813,313	19,445,848	5,476,510
Total value of cotton and cotton-seed oil		263,443,526		192,699,001		216,877,694		211,714,303		195,532,970
Miscellaneous products:										
Broom corn		218,133		163,105		210,712		169,503		181,853
Cider ... gallons	722,959	101,710	732,607	97,352	460,690	65,686	669,745	85,675	372,986	47,670

Cottolene ....pounds..		(1)	569,750	44,832	524,390	39,603	444,045	34,309	1,273,963	78,274
Flowers, cut		(1)		(1)		1,588		2,521		798
Fruits and nuts—										
Apples, dried ....pounds..	26,042,063	1,288,102	7,966,819	482,085	2,846,645	168,054	7,085,946	461,214	26,691,963	1,340,507
Apples, green or ripe...barrels..	938,743	2,407,956	408,014	1,097,967	73,589	242,617	818,711	1,954,318	360,002	930,289
Fruits, preserved—										
Canned		1,558,820		1,137,660		660,723		871,465		1,376,281
Other		214,738		224,381		211,215		47,420		70,353
All other, green, ripe, or dried fruits		1,005,845		881,804		1,016,397		1,522,100		1,868,353
Nuts		60,684		94,902		125,233		115,274		93,283
Ginseng ....pounds..	228,916	803,529	251,205	792,928	194,564	619,114	233,236	826,713	199,436	770,673
Glucose, or grape sugar......do....	96,486,953	2,272,779	101,546,814	2,204,216	124,796,288	2,328,707	133,808,329	2,567,784	171,231,650	2,772,335
Grasses, dried		24,553		33,381		36,205		19,781		44,583
Hay ....tons..	35,201	582,838	33,084	519,640	51,446	890,654	47,117	699,929	59,052	874,048
Hops ....pounds..	12,604,686	2,420,502	11,367,030	2,695,867	17,472,975	3,844,232	17,523,388	1,872,597	16,765,254	1,478,919
Lardine ....do....		(1)	342,017	28,039	497,656	38,291	59,814	3,813	435,960	24,005
Malt ....do....	3,484,534	94,797	3,893,686	85,630	3,056,485	61,186	5,508,187	110,323	6,801,417	126,942
Must		(1)		32,870		51,308		16,000		18,500
Oil cake and oil-cake meal..pounds..	826,398,719	9,713,204	802,416,067	9,688,773	744,603,229	8,807,256	733,652,495	7,165,587	798,366,723	7,949,647
Oils, vegetable, except cotton-seed—										
Linseed ....gallons..	112,386	54,020	103,936	54,356	92,861	48,550	62,718	37,363	67,159	33,260
Volatile or essential		224,919		347,342		274,629		385,414		277,297
Other		73,731		236,101		129,041		106,022		309,955
Plants, trees, and shrubs		34,631		74,663		140,415		129,551		133,735
Rice ....pounds..	10,256,796	89,340	756,992	25,126	763,425	19,884	124,296	4,687	1,346,876	14,117
Rice bran, meal, and polish....do....			12,954,806	128,208	10,002,824	92,255	1,499,040	11,767	13,684,678	79,637
Roots, herbs, and barks, n. e. s.		198,744		194,715		244,438		232,095		153,896
Seeds—										
Clover ....pounds..	19,532,411	1,636,671	8,189,553	988,029	45,418,663	4,540,851	22,900,672	2,124,997	5,539,787	437,493
Cotton ....do....	12,149,261	86,549	4,519,327	35,809	5,419,056	41,866	11,051,812	86,695	26,980,110	179,621
Flaxseed or linseed ....bushels..	3,613,817	3,915,547	1,837,370	2,195,374	2,047,836	2,426,284	1,224	1,433	80,453	73,207
Timothy ....pounds..	10,318,074	381,651	7,077,131	504,937	10,155,867	449,207	4,939,237	277,160	11,894,536	518,755
All other		231,864		269,580		481,013		358,860		382,941
Spices		2,673		1,115		1,205		871		1,367
Starch ....pounds..	20,081,027	612,531	21,938,456	707,093	22,888,016	727,011	11,788,990	366,800	31,829,435	885,198
Straw		(1)		(1)		121		3,639		5,293
Sugar and molasses—										
Molasses and sirup.....gallons..	9,343,214	1,057,216	8,373,286	992,471	9,385,359	1,038,680	9,148,711	850,400	6,953,307	737,870
Sugar, brown............pounds..	245,783	8,682	359,455	13,175	690,080	25,931	695,486	22,052	296,265	10,389
Sugar, refined............do....	14,604,608	665,477	20,386,872	963,123	14,778,416	653,052	8,833,522	406,924	9,106,259	450,753
Sugar meal ....do....		(1)		(1)		(1)		(1)	3,930,412	66,935
Teasels		8,207		1,353		3,487		1,281		6,287
Tobacco—										
Leaf............pounds..	240,716,150	20,303,245	248,367,258	22,292,704	268,791,312	22,939,356	293,805,855	25,622,776	287,700,301	24,405,245
Stems and trimmings .....do....	14,715,927	366,800	17,715,825	599,195	21,893,680	1,145,878	7,186,075	176,192	7,839,011	166,117
Vegetables—										
Beans and peas.........bushels..	637,972	945,767	389,913	745,636	326,748	576,657	242,680	429,002	473,975	632,073
Onions ....do....	59,842	58,121	57,610	60,878	68,865	69,823	53,335	46,703	82,916	61,181
Potatoes ....do....	557,022	361,378	845,720	700,032	803,111	651,877	572,957	418,221	680,049	371,485
Canned vegetables		373,063		242,284		255,857		441,388		407,506

[1] Not separately stated.

Exports of domestic agricultural products from the United States during the five years ending June 30, 1892 to 1896, inclusive—Continued.

Article.	1892.		1893.		1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Miscellaneous products—Continued.										
Vegetables—Continued.										
All other, including pickles and sauces		$159,811		$149,167		$190,248		$208,144		$182,805
Vinegar ... gallons	74,890	11,690	86,936	12,177	68,282	9,537	80,234	11,273	123,163	16,975
Wine—										
In bottles ... dozen	15,054	67,686	11,128	51,654	13,813	63,860	13,919	56,202	17,147	69,460
Not in bottles ... gallons	655,795	371,344	708,558	369,893	802,192	380,588	1,125,297	545,708	1,339,090	581,827
Yeast		(1)		15,911		42,435		44,599		45,077
Total value of miscellaneous products		55,159,553		53,277,833		57,085,937		51,953,645		51,745,070
RECAPITULATION.										
Animals and their products		182,027,147		171,428,673		189,529,928		176,460,118		183,264,812
Breadstuffs		299,363,117		200,312,654		166,777,229		114,604,780		141,356,993
Cotton and cotton-seed oil		263,443,526		192,699,001		216,877,694		211,714,303		195,532,970
Miscellaneous products		55,159,553		53,277,833		57,085,937		51,953,645		51,745,070
Total agricultural exports (domestic)		799,993,343		617,718,161		630,270,788		554,732,846		571,899,845
Total exports (domestic)		1,015,732,011		831,030,785		869,204,937		793,392,599		863,200,487
Per cent agricultural		78.76		74.33		72.51		69.92		66.25

[1] Not separately stated.

Number of cattle and horses exported from the United States to the leading countries of destination during the five years ending June 30, 1896.

Country to which exported.	Cattle. Year ending June 30—					Horses. Year ending June 30—				
	1892.	1893.	1894.	1895.	1896.	1892.	1893.	1894.	1895.	1896.
	Number.	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*	*Number.*
Belgium	3,423	1,440	1,377	4,262	1,411	21		77	300	1,134
France	845		5,184	10,538			2		511	397
Germany	4,643	419	3,069	6,436		28	33	12	1,324	3,686
United Kingdom	378,167	280,996	345,734	305,068	364,193	467	564	1,355	5,834	12,022
Canada	2,123	1,385	537	530	2,701	1,596	1,600	2,639	4,493	5,683
Mexico	3,823	800	654	2,071	1,112	420	457	507	855	987
Other countries	1,583	2,054	2,723	2,817	3,014	694	311	656	667	1,217
Total	394,607	287,094	359,278	331,722	372,461	3,226	2,967	5,246	13,934	25,126

Principal countries to which products of domestic agriculture were exported during the fiscal year ending June 30, 1896.

Article.	Total.	Great Britain and Ireland.	British possessions.	Germany.	France.	All other countries.
Animals:						
Cattle	$34,560,672	$33,984,943	$329,410			$246,319
Hogs	227,297	5,950	8,448			212,899
Horses	3,530,703	1,776,600	736,903	$614,362	$58,600	344,238
Mules	406,161	1,000	133,608			271,553
Sheep	3,076,384	2,647,640	195,870		27,590	205,284
All other, including fowls	39,752	5,090	11,390	9,304		13,968
Total	41,840,969	38,421,223	1,415,629	623,666	86,190	1,294,261
Bones, horns, etc	321,680	98,191	20,812	9,042	62,836	130,799
Breadstuffs:						
Barley	3,100,311	2,257,360	57,855	356,893		428,203
Bread and biscuits	694,323	6,137	402,499	1,469		284,218
Corn	37,836,862	18,719,940	3,401,461	5,121,573	1,624,054	8,969,834
Corn meal	654,121	143,236	380,752	18		130,115
Oats	3,497,611	1,894,798	306,143	199,264	364,028	733,378
Oatmeal	939,502	722,570	14,347	41,685	250	160,650
Rye	445,075	124,612	20,423	112,368		187,672
Rye flour	11,163		975	3		10,185
Wheat	39,709,868	27,906,126	5,385,716	608,450	81,769	5,727,807
Wheat flour	52,025,217	29,108,434	10,017,263	632,569	4,289	12,262,662
All other breadstuffs	2,442,940	826,778	490,859	259,348	7,090	858,865
Total	141,356,993	81,709,991	20,478,293	7,333,640	2,081,480	29,753,589
Broom corn	181,853		160,139	1,730		19,984
Casings for sausages	1,771,680	282,507	141,034	739,075	99,811	509,253
Cider	47,670	46,276	767		30	597
Cotton, unmanufactured	190,056,460	93,050,467	2,869,010	41,759,576	19,506,348	32,871,059
Eggs	48,339	91	38,507	13		9,728
Egg yolks	556	60			496	
Fruits and nuts	5,679,066	2,169,873	1,345,529	715,254	174,456	1,273,954
Feathers	193,046	56,023	17,187	80,054	14,721	25,061
Glucose or grape sugar	2,772,335	2,593,620	122,562	12,095	6,080	37,978
Glue	166,930	43,834	86,696	18,539	1,084	16,777
Flowers, cut	798		795			3
Grease, etc	1,516,763	588,160	353,343	235,128	192,059	148,073
Grasses	44,583	24,465	15	19,319	275	509
Hair, etc	455,880	297,350	19,646	14,900	20,652	103,332
Hay	874,048	599,837	66,790	1,988	226	205,207
Hides and skins, other than fur skins	3,858,946	277,197	1,048,635	1,074,268	1,021,321	437,525
Honey	90,969	58,147	2,925	6,594	8,834	14,469
Hops	1,478,919	1,387,349	74,884	246		16,440
Malt	126,942	16,540	31,294	560		78,548
Must	18,500			18,500		
Oil cake and oil-cake meal	7,949,647	3,506,715	149,455	1,939,558	123,745	2,230,174
Oils:						
Animal	477,240	132,643	184,090	24,584	34,003	101,920
Cotton-seed	5,476,510	631,172	310,180	271,152	1,356,858	2,907,148
Linseed	33,260		4,716			28,544
Total	5,987,010	763,815	498,986	295,736	1,390,861	3,037,612
Provisions:						
Meat products—						
Beef products—						
Beef, canned	5,636,953	3,629,301	414,576	616,540	448,070	528,466
Beef, fresh	18,974,107	18,950,744	17,721			5,642
Beef, salted or pickled	3,975,113	2,119,923	663,740	358,750	32,857	799,843
Beef, other, cured	59,371	30,257	8,839	17,408		2,867
Tallow	2,323,764	796,875	68,678	297,873	357,547	802,791
Total	30,969,308	25,527,100	1,173,554	1,290,571	838,474	2,139,609
Hog products—						
Bacon	33,442,847	27,746,893	473,330	603,022	281,616	4,337,986
Hams	12,669,763	10,066,718	475,009	176,443	60,190	1,891,403
Pork, fresh	43,739	40,103	3,636			
Pork, pickled	3,973,461	750,774	1,889,184	74,992	11,875	1,246,636
Lard	33,589,851	13,521,493	745,119	7,788,975	2,131,390	9,402,874
Total	83,719,661	52,125,981	3,586,278	8,643,432	2,485,071	16,878,899
Mutton	31,793	28,741	1,807	43		1,202

Principal countries to which products of domestic agriculture were exported during the fiscal year ending June 30, 1896—Continued.

Article.	Total.	Great Britain and Ireland.	British possessions.	Germany.	France.	All other countries.
Provisions—Continued.						
Meat products—Continued.						
Oleomargarine—						
Imitation butter	$587,269	$24,730	$181,106	$197,548		$183,885
The oil	8,087,905	664,943	94,620	1,575,906	$10,841	5,741,595
Total	8,675,174	689,673	275,726	1,773,454	10,841	5,925,480
Poultry and game	40,647	19,912	17,774	102		2,859
All other meat products	1,767,437	905,016	212,469	204,750	73,750	371,452
Dairy products -						
Butter	2,937,203	1,768,453	310,839	139,762	30	718,119
Cheese	3,091,914	2,491,088	512,142	628		88,056
Milk	270,453	27,509	50,944	36	52	191,912
Total	6,299,570	4,287,050	873,925	140,426	82	998,087
Total provisions	131,503,590	83,583,473	6,141,533	12,052,778	3,408,218	26,[illegible],588
Rice	14,117	4,842	666	164		8,445
Roots, herbs, etc	153,896	51,234	13,910	44,312	6,271	38,136
Seeds:						
Clover	437,493	75,261	258,231	76,199	1,099	26,703
Cotton	179,621	177,451	388	618	7	1,157
Flaxseed or linseed	73,207	8,002	30,541		465	34,199
Timothy	518,755	106,046	311,510	68,812	8,640	23,747
All other	382,941	118,769	74,557	42,985	24,993	121,637
Total	1,592,017	485,529	675,227	188,614	35,204	207,443
Straw	5,293	5,225	68			
Sugar, brown, molasses, and sirup	748,259	498,190	78,155	31,618		140,296
Tobacco, leaf, stems, and trimmings	24,571,362	8,265,289	1,768,502	3,034,342	2,614,605	8,888,624
Vegetables:						
Beans and peas	632,073	154,230	137,702	6,760	3,255	330,126
Onions	61,181	2,166	21,585	80		37,350
Potatoes	371,185	1,412	55,611	27		314,405
Vegetables, canned	407,506	284,772	50,217	1,753	2,640	68,124
All other, including pickles	182,805	29,368	92,693	241	142	60,361
Total	1,655,050	471,948	357,838	8,861	6,037	810,366
Wax, bees'	65,844	37,261	827	21,188		6,568
Wine	651,287	111,081	15,446	77,167	4,793	442,800
Wool	855,950	174,445	312,552	28,516	47,968	292,469
Total [1]	568,657,247	319,680,248	38,307,657	70,387,071	30,914,604	109,367,667
Per cent		56.22	6.74	12.38	5.43	19.23

[1] Unenumerated articles, amounting to $3,242,598, make up the total to $571,899,845.

Quantities of cheese exported from the United States to the leading countries of destination during the five years ending June 30, 1896.

Country to which exported.	Year ending June 30— 1892.	1893.	1894.	1895.	1896.	Annual average, 1892–1896.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*P. ct.*
United Kingdom	70,201,769	69,845,314	61,459,757	48,286,660	29,801,334	55,918,967	83.6
Canada	9,561,251	9,107,977	10,081,785	10,287,839	5,254,494	8,858,669	13.2
Mexico	126,577	158,571	109,876	112,421	110,142	123,517	.2
British West Indies	670,520	724,783	722,717	696,381	655,320	693,944	1.0
Haiti	134,699	123,242	109,672	106,668	80,896	111,035	.2
Cuba	202,611	225,421	215,021	52,680	42,896	147,726	.2
Puerto Rico	247,532	244,884	130,545	25,319	25,404	134,737	.2
British Guiana	261,007	270,556	354,630	240,397	136,283	252,575	.4
Hawaii	86,751	77,158	80,787	87,615	93,795	85,221	.1
Other countries	607,504	573,017	587,344	532,441	576,727	579,407	.9
Total	82,100,221	81,350,923	73,852,134	60,448,421	36,777,291	66,905,798	100.0

Imports of agricultural products into the United States during the five years ending June 30, 1892 to 1896, inclusive.

Article.	1892.		1893.		1894.		1895.		1896.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Animals, and their products, except wool:										
Animals, live—										
Cattle ....number..	2,168	$47,466	3,293	$45,682	1,592	$18,704	149,781	$765,853	217,826	$1,509,853
Horses ....do....	14,074	2,455,868	15,451	2,388,267	6,166	1,319,572	13,098	1,055,191	9,991	662,591
Sheep ....do....	380,814	1,440,530	459,484	1,682,977	242,568	788,181	291,461	682,618	322,692	853,530
All other, including fowls	....	307,752	....	525,269	....	274,780	....	233,416	....	226,500
Animal products, except wool—										
Beeswax ....pounds..	271,068	65,487	248,000	62,024	318,660	80,024	288,001	78,776	273,464	75,970
Bones, crude	....	345,668	....	360,573	....	307,033	....	306,049	....	157,946
Bristles ....pounds..	1,495,003	1,455,058	1,598,818	1,508,258	892,520	929,231	1,301,494	1,244,151	1,572,530	1,435,348
Dairy products—										
Butter ....do....	114,137	16,549	73,423	13,479	144,346	23,356	72,148	12,930	52,067	8,533
Cheese ....do....	8,305,288	1,238,166	10,195,924	1,425,927	8,742,851	1,247,198	10,276,293	1,450,657	10,728,397	1,491,338
Milk	....	95,947	....	118,186	....	102,336	....	80,491	....	62,622
Eggs ....dozen..	4,188,492	522,240	3,318,011	382,973	1,791,450	199,536	2,705,502	324,136	947,132	88,682
Feathers and downs, crude	....	443,776	....	654,337	....	263,849	....	1,746,967	....	2,386,804
Gelatin	....	(1)	....	(1)	....	(1)	....	(1)	....	15,386
Glue ....pounds..	5,541,776	495,519	6,170,162	567,756	4,132,524	400,240	4,751,048	416,394	6,276,926	555,979
Grease	....	271,421	....	419,625	....	256,287	....	1,331,908	....	1,252,001
Gut, unmanufactured	....	225,278	....	229,261	....	188,111	....	212,645	....	195,362
Hair	....	1,685,562	....	2,605,796	....	839,072	....	1,165,944	....	1,244,077
Hide cuttings and all other glue stock	....	303,302	....	385,525	....	280,062	....	263,175	....	279,692
Hides and skins ....pounds..	....	26,850,218	....	28,347,896	....	16,786,152	226,575,745	26,122,942	210,398,011	30,520,177
Honey ....gallons..	70,103	31,418	176,147	79,398	152,643	56,156	67,444	22,993	79,985	30,609
Hoofs, horns, and parts of, unmanufactured	....	797,529	....	554,902	....	235,232	....	268,800	....	568,445
Meat and meat extracts	....	430,048	....	558,284	....	412,666	....	479,336	....	493,393
Meat products, n. e. s	....	15,386	....	16,717	....	12,291	....	5,244	....	39,129
Oils, animal ....gallons..	34,543	12,136	55,619	21,327	3,597	1,232	1,464	469	37,330	12,213
Oleostearin ....pounds..	....	(1)	....	(1)	....	(1)	....	(1)	523,341	37,020
Rennets	....	116,460	....	109,358	....	76,063	....	84,415	....	51,073
Sausage, bologna ....pounds..	....	82,507	....	98,659	....	102,610	....	93,188	359,260	80,887
Sausage skins	....	566,650	....	583,217	....	495,118	....	419,345	....	588,657
Total value of animals and their products, except wool	....	40,317,941	....	43,127,671	....	25,696,001	....	38,868,033	....	44,903,820
Breadstuffs:										
Barley ....bushels..	3,146,328	1,592,040	1,970,129	921,605	791,061	358,744	2,116,816	867,743	837,384	317,209
Corn (maize) ....do....	15,290	10,752	1,881	1,265	2,199	1,508	16,575	7,552	4,338	1,877
Oats ....bushels..	20,208	8,224	21,309	8,897	8,345	3,928	308,308	80,901	47,506	13,039
Oatmeal ....pounds..	496,333	27,942	506,232	25,642	421,459	24,483	396,176	21,993	343,732	19,689
Rye ....bushels..	83,537	67,597	8,598	7,055	50	37	12,918	6,272	154	291
Wheat ....do....	2,459,602	1,955,385	966,280	707,053	1,121,060	769,177	1,429,993	868,965	2,110,030	1,383,161

[1] Not separately stated.

Imports of agricultural products into the United States during the five years ending June 30, 1892 to 1896, inclusive—Continued.

Article.	1892. Quantity.	1892. Value.	1893. Quantity.	1893. Value.	1894. Quantity.	1894. Value.	1895. Quantity.	1895. Value.	1896. Quantity.	1896. Value.
Breadstuffs—Continued.										
Wheat flour ....barrels..	614	$4,231	410	$2,223	401	$1,946	1,868	$8,295	1,394	$6,848
All other, and preparations of, used as food........	....	1,223,066	....	1,266,835	....	1,042,064	....	998,092	....	1,035,700
Total value of breadstuffs......	....	4,889,147	....	2,940,575	....	2,201,887	....	2,859,813	....	2,780,814
Fibers:										
Animal—										
Silk ....pounds..	8,834,049	25,059,325	8,497,477	29,836,986	5,902,485	16,234,182	9,316,460	22,626,056	9,363,987	26,763,428
Wool ....do....	148,670,652	19,688,108	172,433,838	21,064,180	55,152,585	6,107,438	206,033,906	25,556,421	230,911,473	32,451,242
Vegetable—										
Cotton........do....	28,663,769	3,217,521	43,367,952	4,688,799	27,705,949	3,003,888	49,332,022	4,714,375	55,350,520	6,578,212
Flax ....tons..	7,812	1,964,163	6,696	1,879,152	4,352	1,336,845	7,233	2,059,291	7,833	1,804,428
Hemp ....do....	5,187	681,809	4,817	685,485	1,635	239,918	6,954	882,761	8,450	1,069,503
Istle, or tampico fiber......do....	4,732	325,548	4,987	321,869	4,789	257,089	9,827	458,404	12,207	717,585
Jute and jute butts........do....	88,624	3,021,174	82,231	2,467,828	50,037	1,716,298	110,671	2,752,966	88,992	2,001,206
Manila ....do....	44,574	6,672,279	59,439	8,376,370	35,233	4,013,255	50,278	4,060,517	47,244	3,604,585
Sisal grass ....do....	48,020	5,187,620	54,431	6,005,484	48,468	3,742,073	47,596	2,743,396	52,130	3,412,760
All other........do....	12,824	1,271,501	16,303	1,635,367	10,207	858,003	6,152	324,746	6,336	260,627
Total value of fibers	....	67,089,048	....	76,961,520	....	37,508,989	....	66,178,933	....	78,663,576
Sugar and molasses:										
Sugar ....pounds..	3,556,509,165	104,408,813	3,766,445,347	116,255,784	4,345,193,881	126,871,889	3,574,510,454	76,462,836	3,896,338,557	89,219,773
Molasses ....gallons..	22,448,209	2,877,744	15,490,679	1,992,334	19,670,663	1,984,778	15,075,879	1,295,146	4,687,664	737,265
Total value of sugar and molasses	....	107,286,557	....	118,248,118	....	128,856,667	....	77,757,982	....	89,957,038
Tea, coffee, cocoa, and substitutes:										
Tea........pounds..	90,079,039	14,373,222	89,061,287	15,857,482	93,518,717	14,144,243	97,253,458	13,171,379	93,998,372	12,704,440
Coffee ....do....	640,210,788	128,041,930	563,469,068	80,485,558	550,934,337	90,314,676	652,208,975	96,130,717	580,597,915	84,793,124
Cocoa, crude, and leaves and shells of........pounds..	21,955,874	3,221,041	24,460,325	4,017,801	17,634,779	2,402,382	29,307,048	3,195,811	23,276,597	2,387,078
Chicory root, raw, unground...do....	5,492,732	93,179	6,689,332	134,070	7,951,042	168,292	9,544,186	158,142	15,841,955	210,228
Coffee substitutes, n. e. s........do....	2,184,348	83,159	1,729,124	64,298	1,389,672	55,554	2,776,117	106,886	2,366,962	90,532
Total value of tea, coffee, cocoa, and substitutes........	....	145,812,531	....	98,559,209	....	107,085,747	....	112,762,935	....	100,185,402
Miscellaneous products:										
Flowers, natural, dressed or undressed	....	30,782	....	55,046	....	41,445	....	10,014	....	10,386
Fruit juices—										
Cherry juice, and fruit juices, n. e. s	....	37,307	....	36,601	....	17,452	....	26,470	....	47,285
Prune juice or prune wine.galls..	26,774	27,716	22,365	19,481	31,792	27,406	39,011	28,826	34,422	28,566
Fruits and nuts	....	20,943,906	....	23,687,422	....	18,754,771	....	17,239,923	....	19,032,439

Hay ... tons	79,715	715,151	104,257	964,755	86,784	761,940	201,900	1,433,716	302,652	2,773,535
Hops ... pounds	2,506,224	883,701	2,691,244	1,085,407	828,022	484,415	3,133,664	599,744	2,772,045	600,419
Indigo ... do	2,461,667	1,772,507	3,226,312	3,137,511	1,718,534	1,218,576	3,956,986	2,015,975	3,340,001	1,673,170
Malt, barley ... bushels	5,165	6,148	3,559	4,411	5,010	5,676	11,069	7,495	5,579	4,774
Oil cake ... pounds	10,366,156	106,811	7,302,527	82,916	7,600,871	37,588	6,794,531	47,774	7,473,016	45,725
Oils, vegetable—										
Fixed or expressed—										
Olive, salad ... gallons	706,486	876,613	686,852	891,424	757,478	909,897	775,046	952,405	942,598	1,107,049
Other		2,239,540		2,754,372		1,730,797		2,570,035		2,557,026
Volatile or essential ... pounds	3,451,519	1,676,064	4,022,117	1,654,036	2,861,875	1,102,108		1,398,956		1,554,289
Opium, crude ... pounds	587,118	1,029,203	615,957	1,186,824	716,881	1,691,914	358,455	730,669	365,514	683,347
Plants, trees, shrubs, vines, etc		155,018		137,503		124,143		632,523		955,307
Rice and rice meal ... pounds	148,103,688	3,030,883	147,483,828	2,790,151	142,161,817	2,374,835	219,564,320	3,445,512	146,724,607	2,185,579
Sauerkraut		3,728		39,153		16,652		25,898		7,895
Seeds		2,264,837		2,757,010		2,395,603		6,535,580		2,683,154
Spices—										
Ground ... pounds	2,381,248	307,738	2,488,466	298,008	1,664,246	257,845	2,058,782	272,223	2,618,214	294,996
Unground—										
Nutmegs ... do	1,580,605	750,813	1,419,636	613,743	1,140,878	395,977	1,652,613	513,801	1,355,420	433,436
Pepper ... do	14,799,322	1,069,268	21,467,275	1,278,062	12,764,215	665,576	20,501,837	791,343	16,644,763	650,861
All other ... do	14,511,451	920,006	16,862,214	1,110,197	14,857,688	943,155	17,879,564	1,062,868	19,193,589	999,226
Starch ... do	843,304	22,829	3,855,437	90,483	2,045,216	42,606	4,265,650	82,150	3,467,399	62,756
Straw ... tons	5,002	18,798	8,892	30,681	8,313	27,360	7,745	24,544	7,879	31,149
Tobacco, leaf ... pounds	21,988,535	10,332,423	28,110,378	14,702,440	19,663,259	10,985,386	26,668,261	14,745,720	32,924,966	16,503,130
Vanilla beans ... do	242,639	803,696	238,733	763,935	171,556	727,853	137,295	495,273	235,763	1,013,608
Vegetables—										
Beans and peas ... bushels	874,050	957,824	1,754,943	1,734,228	1,184,081	1,117,969	1,535,960	1,548,767	613,801	658,320
Potatoes ... do	186,871	186,006	4,317,021	2,066,589	3,002,578	1,277,394	1,341,533	603,554	175,240	127,595
Pickles and sauces		421,292		454,099		341,135		321,632		324,377
All other		1,318,105		1,331,773		1,158,769		1,497,583		1,466,558
Vinegar ... gallons	67,970	18,191	66,834	19,295	68,542	18,501	75,108	19,823	81,075	24,552
Wines—										
Champagne and other sparkling, dozen bottles	319,592	4,571,816	374,124	5,579,054	237,360	3,498,522	257,757	3,807,961	246,393	3,628,319
Still wines—										
In casks ... gallons	3,477,989	2,464,484	3,525,625	2,505,024	2,599,693	1,817,813	2,789,153	1,945,347	2,834,898	1,950,770
In bottles ... dozen	385,140	1,908,203	413,860	2,121,275	296,097	1,423,143	296,779	1,430,229	314,190	1,527,916
Total value of miscellaneous products		61,871,398		75,982,909		56,393,962		66,864,333		65,647,505
RECAPITULATION.										
Animals and their products, except wool		49,317,941		43,127,671		25,696,001		38,868,633		44,903,820
Breadstuffs		4,889,147		2,940,575		2,201,887		2,859,813		2,780,814
Fibers		67,089,048		76,961,520		37,508,989		66,178,933		78,663,576
Sugar and molasses		107,286,557		118,248,118		128,856,667		77,757,982		89,957,058
Tea, coffee, cocoa, and substitutes		145,812,531		98,559,209		107,085,747		112,762,935		100,185,402
Miscellaneous products		61,871,398		75,982,909		56,393,962		66,864,333		65,647,505
Total agricultural imports		427,266,622		415,820,602		357,743,253		365,292,029		382,138,155
Total imports		827,402,462		866,400,922		654,994,622		731,969,965		779,724,674
Per cent agricultural		51.64		47.99		54.62		49.91		49.01

Quantities of sugar imported into the United States from the leading countries of supply during the five years ending June 30, 1896.

Country from which imported.	Year ending June 30—				
	1892.	1893.	1894.	1895.	1896.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Austria-Hungary	69,943,241	34,391,679	44,536,822	7,411,234	40,703,929
Belgium	38,919,574	71,322,733	80,479,170	24,338,139	72,721,186
France	10,195,056	157,204	13,909,622	35,832	31,810,370
Germany	177,620,486	326,827,509	358,649,535	311,182,968	525,931,657
Netherlands	466,780	2,717,110	23,829,548	12,600,263	40,965,863
United Kingdom	6,834,696	31,964,310	58,241,116	49,610,295	56,992,162
Canada	3,293,143	20,480,193	3,846,249	8,329,961	1,304,887
British West Indies	259,249,702	332,968,755	256,821,752	193,498,237	217,421,118
Danish West Indies	9,041,406	13,894,070	15,558,546	9,131,589	12,202,619
Santo Domingo	62,615,068	64,036,960	89,421,821	66,492,169	116,972,841
Cuba	1,983,540,022	1,843,652,253	2,127,502,319	1,845,763,398	1,093,171,312
Puerto Rico	80,474,547	99,617,911	75,546,030	56,352,954	81,582,810
Brazil	178,404,072	114,598,997	258,447,122	180,262,039	191,457,878
British Guiana	139,570,854	159,061,559	134,455,359	110,848,960	146,433,256
Dutch Guiana	7,132,576	14,798,065	12,787,452	8,794,544	12,299,669
China	6,855,086	10,575,216	21,189,075	23,696,923	31,827,859
Dutch East Indies	140,956,946	183,492,832	258,013,620	280,464,270	567,670,780
Hongkong	2,906,073	7,847,396	11,203,629	8,351,495	12,046,973
Hawaii	262,612,405	289,553,529	326,574,584	274,385,228	352,175,269
Philippine Islands	97,285,662	122,413,780	124,052,343	68,770,492	145,075,344
British Africa	8,031,573	----------	8,595,345	3,776,030	26,564,115
Egypt	7,885,003	9,715,060	----------	23,250,815	100,335,317
Other countries	2,675,194	12,358,226	11,532,522	16,162,679	15,611,403
Total	3,556,509,165	3,766,445,347	4,345,193,881	3,574,510,454	3,896,338,557

Quantities of unmanufactured wool imported into the United States from the leading countries of supply during the five years ending June 30, 1896.

Country from which imported.	Year ending June 30—				
	1892.	1893.	1894.	1895.	1896.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Belgium	130,238	123,869	48	3,463,983	9,210,716
France	4,882,555	8,128,213	962,734	10,245,426	13,279,720
Germany	415,815	1,481,560	246,389	1,235,315	2,021,443
Russia	32,460,709	30,835,233	9,055,037	12,388,082	9,945,248
Turkey, European	2,458,942	3,238,602	1,153,128	2,819,710	5,803,833
United Kingdom	43,473,171	61,107,704	11,546,327	78,391,661	90,907,989
Canada	1,137,216	1,402,858	692,628	7,031,178	4,964,753
Argentina	14,127,791	13,842,868	8,983,667	25,745,854	22,736,851
Chile	2,374,910	1,644,889	1,418,219	2,149,749	3,438,140
Uruguay	4,832,563	652,030	247,797	10,347,873	8,114,961
China	13,889,957	20,753,893	10,186,264	26,089,418	24,547,088
British East Indies	568,605	403,937	267,047	884,272	123,237
Turkey, Asiatic	9,194,835	13,316,552	3,904,201	7,329,877	5,453,664
British Australasia	15,359,722	9,176,282	4,917,396	12,383,814	20,386,269
British Africa	1,143,112	2,134,255	1,221,742	3,871,253	8,252,441
Other countries	2,220,511	4,191,093	439,961	1,656,441	1,725,120
Total	148,670,652	172,433,838	55,152,585	206,033,906	230,911,473

STATISTICS OF FRUIT AND VEGETABLE CANNING IN THE UNITED STATES.

[From the Census of 1890.]

Capital employed	$15,315,185
Average number of employees	50,881
Wages paid during the year	$5,243,707
Cost of materials used	$18,665,163
Total value of products	$29,862,416

The capital employed in this industry was only $701,388 less than was employed in the creamery and cheese-factory business, while the value of the products exceeded the combined value of all the windmills, clocks, watches, firearms, mirrors, mats and matting, linen fabrics, and enameled goods manufactured in the United States during the same year.

AVERAGE PRICE AND CONSUMPTION OF SUGAR.

Average price per pound of "Standard A" sugar in the New York market and average consumption of sugar of all grades, per capita of population, in the United States from 1878 to 1895.

Calendar year—	Average price per pound.	Consumption per capita of population.	Calendar year—	Average price per pound.	Consumption per capita of population.
	Cents.	*Pounds.*		*Cents.*	*Pounds.*
1878	8.94	34.3	1887	5.66	52.7
1879	8.53	40.7	1888	6.69	56.7
1880	9.48	42.9	1889	7.59	51.8
1881	9.84	44.2	1890	6.00	52.8
1882	8.87	48.4	1891	4.47	66.1
1883	8.14	51.1	1892	4.21	63.5
1884	6.37	53.4	1893	4.72	63.9
1885	6.06	51.8	1894	4.00	66.0
1886	5.81	56.9	1895	4.00	62.6

TEA, COFFEE, WINES, ETC.

Consumption of tea, coffee, wines, distilled spirits, and malt liquors in the United States for the years 1870 to 1896, per capita of population.

Year ending June 30—	Tea.	Coffee.	Wines.	Distilled spirits.	Malt liquors.
	Pounds.	*Pounds.*	*Gallons.*	*Proof gals.*	*Gallons.*
1870	1.10	6.00	0.32	2.07	5.31
1871	1.14	7.91	.40	1.62	6.10
1872	1.46	7.28	.41	1.68	6.66
1873	1.53	6.87	.45	1.63	7.21
1874	1.27	6.59	.48	1.51	7.00
1875	1.44	7.08	.45	1.50	6.71
1876	1.35	7.33	.45	1.33	6.83
1877	1.23	6.94	.47	1.28	6.58
1878	1.33	6.24	.47	1.09	6.68
1879	1.21	7.42	.50	1.11	7.05
1880	1.39	8.78	.56	1.27	8.26
1881	1.54	8.25	.47	1.38	8.65
1882	1.47	8.30	.49	1.40	10.03
1883	1.30	8.91	.48	1.46	10.27
1884	1.09	9.26	.37	1.48	10.74
1885	1.18	9.60	.39	1.26	10.62
1886	1.37	9.36	.45	1.26	11.20
1887	1.49	8.53	.55	1.21	11.23
1888	1.40	6.81	.61	1.26	12.80
1889	1.29	9.16	.56	1.32	12.72
1890	1.33	7.83	.46	1.40	13.67
1891	1.29	7.99	.45	1.42	15.28
1892	1.37	9.61	.44	1.50	15.10
1893	1.32	8.24	.48	1.51	16.08
1894	1.34	8.01	.31	1.33	15.18
1895	1.38	9.22	.28	1.12	14.95
1896	1.31	8.04	.26	1.00	15.16

TOTAL VALUES OF EXPORTS OF DOMESTIC MERCHANDISE FOR THE YEARS 1890 TO 1896.

Year ending June 30—	Agricultural.		Other nonmanufactured.		Manufactured.		Total value.
	Value.	Per cent.	Value.	Per cent.	Value.	Per cent.	
1890	$629,820,808	74.51	$64,370,644	7.62	$151,102,376	17.87	$845,293,828
1891	642,751,344	73.69	60,591,624	6.94	168,927,315	19.37	872,270,283
1892	799,328,232	78.69	57,892,842	5.70	158,510,937	15.61	1,015,732,011
1893	615,382,986	74.05	57,624,681	6.93	158,023,118	19.02	831,030,785
1894	628,363,038	72.28	57,113,091	6.58	183,728,808	21.14	869,204,937
1895	553,210,026	69.73	56,586,830	7.13	183,595,743	23.14	793,392,599
1896	571,899,845	66.25	62,729,464	7.27	228,571,178	26.48	863,200,487

EXPORTS OF RAW COTTON FROM THE UNITED STATES FOR THE YEARS 1890 TO 1896.

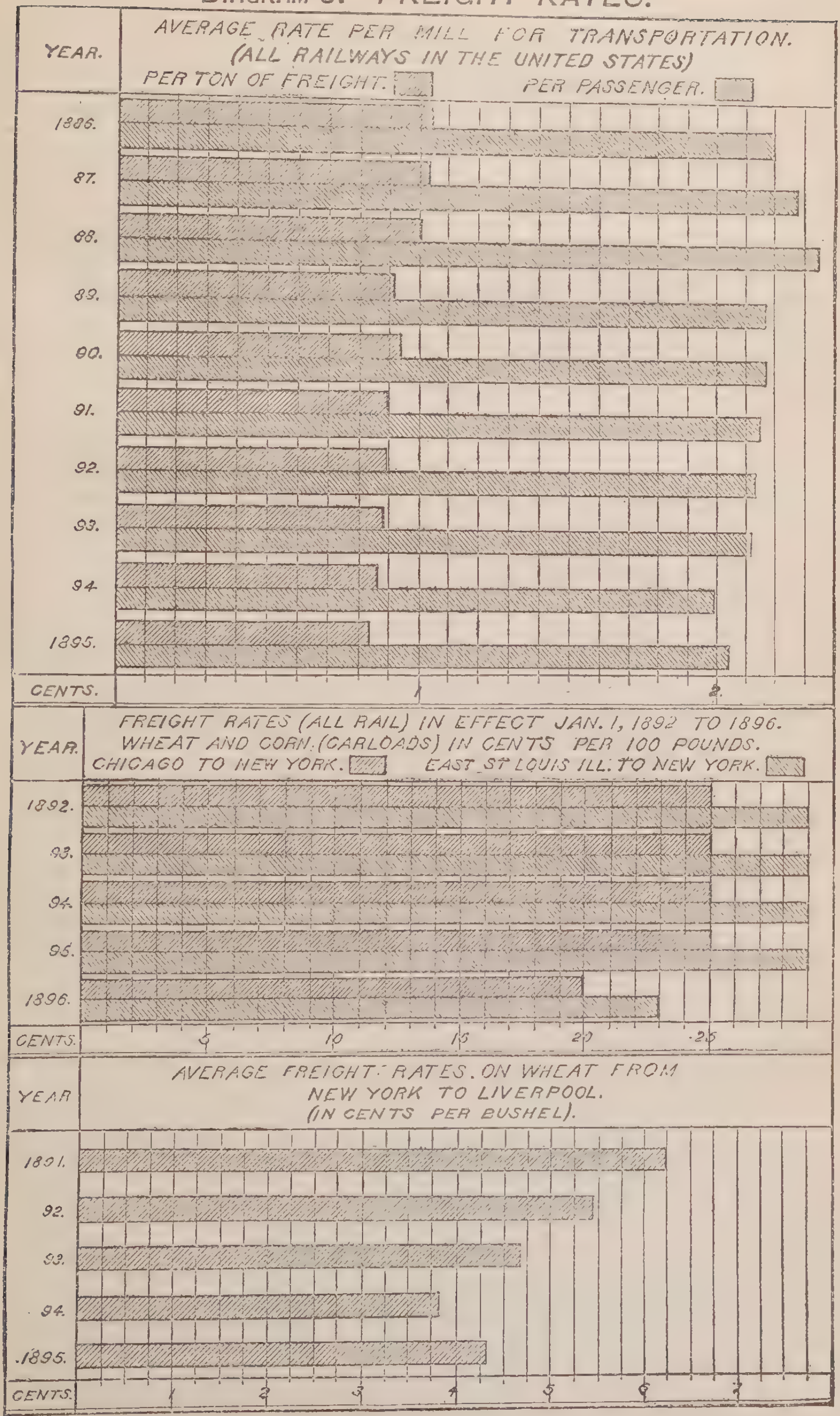
Year ending June 30—	Pounds.	Per cent of total crop.	Average export price per pound.
			Cents.
1890	2,471,799,853	68.15	10.1
1891	2,907,358,795	67.36	10.0
1892	2,935,219,811	65.13	8.7
1893	2,212,115,126	65.99	8.5
1894	2,683,282,325	71.20	7.8
1895	3,517,433,109	69.83	5.8
1896	2,335,226,385	65.00	8.1

PRODUCTION OF CERTAIN FRUITS AND NUTS, MOSTLY SEMI-TROPIC, IN THE UNITED STATES IN 1889, AND THE QUANTITIES AND VALUES IMPORTED FROM 1891 TO 1896, INCLUSIVE.

Product.	Total value of United States crop in 1889.	Imported during year ending June 30—					
		1891.	1892.	1893.	1894.	1895.	1896.
Oranges	[1] $6,602,099	$2,339,987	$1,210,338	$1,695,469	$1,127,005	$1,997,266	$2,694,131
Lemons	988,100	4,351,970	4,548,263	4,994,328	4,285,278	3,917,326	5,040,344
Limes	[1] 62,497	[2] 59,867	[2] 37,829	[2] 47,196	[2] 48,764	[2] 28,104	[2] 39,602
Bananas	[1] 280,654	5,854,752	5,000,632	5,361,187	5,122,503	4,674,861	4,502,746
Figs	[1] 307,272	697,562	511,142	548,995	392,040	587,420	639,512
		[3] 9,201,565	[3] 8,338,759	[3] 10,503,928	[3] 7,985,959	[3] 11,855,890	[3] 11,900,710
Dates	[4]	[2] 661,596	551,629	493,910	387,586	316,592	273,456
		[5] 20,091,012	[3] 17,084,557	[3] 16,211,906	[3] 12,408,192	[3] 15,186,789	[3] 13,680,302
Cocoanuts	251,217	918,233	917,564	852,509	786,777	471,994	442,739
Pineapples	[1] 812,159	[2] 558,288	[2] 746,561	[2] 743,861	[2] 753,129	[2] 314,039	[2] 332,068
Olives	386,368	[2] 320,164	[2] 417,882	[2] 510,535	[2] 378,863	[2] 325,352	[2] 347,345
Raisins	2,195,512	2,018,879	964,309	1,266,342	554,081	651,420	460,200
	[3] 27,443,900	[3] 39,572,655	[3] 20,687,640	[3] 27,543,563	[3] 13,751,050	[3] 15,921,278	[3] 10,826,094
Currants	[4]	[2] 1,577,852	1,209,119	1,185,537	774,802	258,659	551,072
		[5] 42,849,814	[3] 36,665,828	[3] 33,166,546	[3] 52,664,843	[3] 16,450,706	[3] 33,040,846
Plums and prunes	[3] 127,719,600	2,054,486	437,271	1,162,318	416,342	527,625	68,862
	[4]	[3] 34,281,322	[3] 10,869,797	[3] 26,414,112	[3] 9,908,122	[3] 14,352,057	[3] 483,658
Almonds	1,525,110	931,007	1,028,671	938,054	769,453	810,439	763,594
		[3] 6,812,061	[3] 7,629,392	[3] 6,679,147	[3] 7,436,784	[3] 7,903,375	[3] 7,789,681

[1] Returns from a few districts not quite complete.
[2] Entered for consumption.
[3] Quantity in pounds.
[4] Value of crop not ascertained.
[5] Quantity in pounds entered for consumption.

DIAGRAM 8.—FREIGHT RATES.



FREIGHT RATES.

Rates (all rail) in effect January 1, 1893 to 1897 (in cents per 100 pounds).

From—	To—	Wheat (car loads). 1893.	1894.	1895.	1896.	1897.	Corn (car loads). 1893.	1894.	1895.	1896.	1897.	Potatoes (car loads). 1893.	1894.	1895.	1896.	1897.	Wool in bales (car loads). 1893.	1894.	1895.	1896.	1897.	Pickled pork, in barrels (car loads). 1893.	1894.	1895.	1896.	1897.
Cincinnati, Ohio	Boston, Mass.[1]	23½	23½	23½	19	19½	23½	23½	23½	19	19½	29	29	29	29	29	52	62½	62½	62½	39	29	29	29	29	29
	New York, N. Y.	21½	21½	21½	17	17½	21½	21½	21½	17	17½	26	26	26	26	26	46	56½	56½	56½	34	26	26	26	26	26
	Philadelphia, Pa.	19½	19½	19½	15	15½	19½	19½	19½	15	15½	24	24	24	24	24	44	54½	54½	54½	32	24	24	24	24	24
	Baltimore, Md.	18½	18½	18½	14	14½	18½	18½	18½	14	14½	23	23	23	23	23	43	53½	53½	53½	31	23	23	23	23	23
Indianapolis, Ind.	Boston, Mass.[1]	25	25	25	21½	20½	25	25	25	21½	20½	31	31	31	31	31	56½	66½	66½	66½	41½	31	31	31	31	31
	New York, N. Y.	23	23	23	19½	18½	23	23	23	19½	18½	28	28	28	28	28	49½	60	60	60	35½	28	28	28	28	28
	Philadelphia, Pa	21	21	21	17½	16½	21	21	21	17½	16½	26	26	26	26	26	47½	58½	58½	58½	34½	26	26	26	26	26
	Baltimore, Md.	20	20	20	16½	15½	20	20	20	16½	15½	25	25	25	25	25	46½	57½	57½	57½	33½	25	25	25	25	25
Chicago, Ill	Boston, Mass.[1]	27	27	27	22	22	27	27	27	22	22	33	33	33	33	33	59	71	71	71	44	33	33	33	33	33
	New York, N. Y.	25	25	25	20	20	25	25	25	20	20	30	30	30	30	30	53	65	65	65	39	30	30	30	30	30
	Philadelphia, Pa.	23	23	23	18	18	23	23	23	18	18	28	28	28	28	28	51	63	63	63	37	28	28	28	28	25
	Baltimore, Md.	22	22	22	17	17	22	22	22	17	17	27	27	27	27	27	50	62	62	62	36	27	27	27	27	27
East St. Louis, Ill.	Boston, Mass.[1]	31	31	31	25	25	31	31	31	25	25	38	38	38	38	38	63½	81½	81½	81½	50	38	38	38	38	38
	New York, N. Y.	29	29	29	23	23	29	29	29	23	23	35	35	35	35	35	61½	75½	75½	75½	45	35	35	35	35	35
	Philadelphia, Pa.	27	27	27	21	21	27	27	27	21	21	33	33	33	33	33	59½	73½	73½	73½	43	33	33	33	33	33
	Baltimore, Md.	26	26	25	29	20	26	26	26	20	20	32	32	32	32	32	58½	72½	72½	72½	42	32	32	32	32	32

Rates on wheat from New York to Liverpool (in cents per bushel).

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1875	21.94	18.82	14.56	12.34	13.94	16.00	......	......	......	......	......	......
1880	7.00	7.62	12.00	11.90	9.00	10.12	14.60	14.76	11.38	12.30	15.12	14.62
1885	9.30	5.32	7.30	8.38	5.60	5.00	4.76	5.30	7.72	5.70	5.12	6.48
1890	11.13	10.75	8.00	4.00	4.13	3.75	4.25	2.00	1.38	.38	4.50	5.00
1891	7.25	4.75	3.00	3.00	3.25	4.00	4.00	6.00	8.63	11.13	11.50	8.75
1892	9.00	6.38	7.50	3.75	4.88	4.00	5.50	4.25	4.00	6.00	4.88	......
1893	3.00	3.25	2.75	2.63	3.75	5.88	6.50	7.13	4.38	5.25	6.00	5.88
1894	6.25	4.75	4.63	4.25	2.38	3.50	2.88	1.63	1.75	2.25	5.63	5.88
1895	3.38	3.88	4.37	3.88	3.50	2.25	3.25	3.88	4.75	5.62	6.62	6.38
1896	6.12	4.50	3.25	3.88	4.12	4.00	4.00	5.25	8.00	9.88	10.38	7.12

Rates (all rail) on live stock and dressed meats from Chicago to New York (in cents per 100 pounds).

Year.	Cattle.	Hogs.	Sheep.	Horses and mules.	Dressed beef.	Dressed hogs, refrigerator cars.	Dressed hogs, common cars.
1875	......	......	......	......	70.00	......	......
1880	55.00	41.25	65.00	65.00	88.00	......	......
1885	29.00	25.00	42.00	60.00	50.60	......	......
1890	21.69	25.42	30.00	50.90	37.40	37.40	37.40
1891	28.00	30.00	30.00	60.00	45.00	45.00	45.00
1892	28.00	24.37	30.00	60.00	45.00	45.00	45.00
1893	28.00	20.00	30.00	60.00	45.00	45.00	45.00
1894	28.00	28.33	30.00	60.00	45.00	45.00	45.00
1895	28.00	25.00	30.00	60.00	45.00	45.00	45.00
1896	28.00	30.00	30.00	60.00	45.00	45.00	45.00

[1] On traffic for export New York rates apply to Boston.

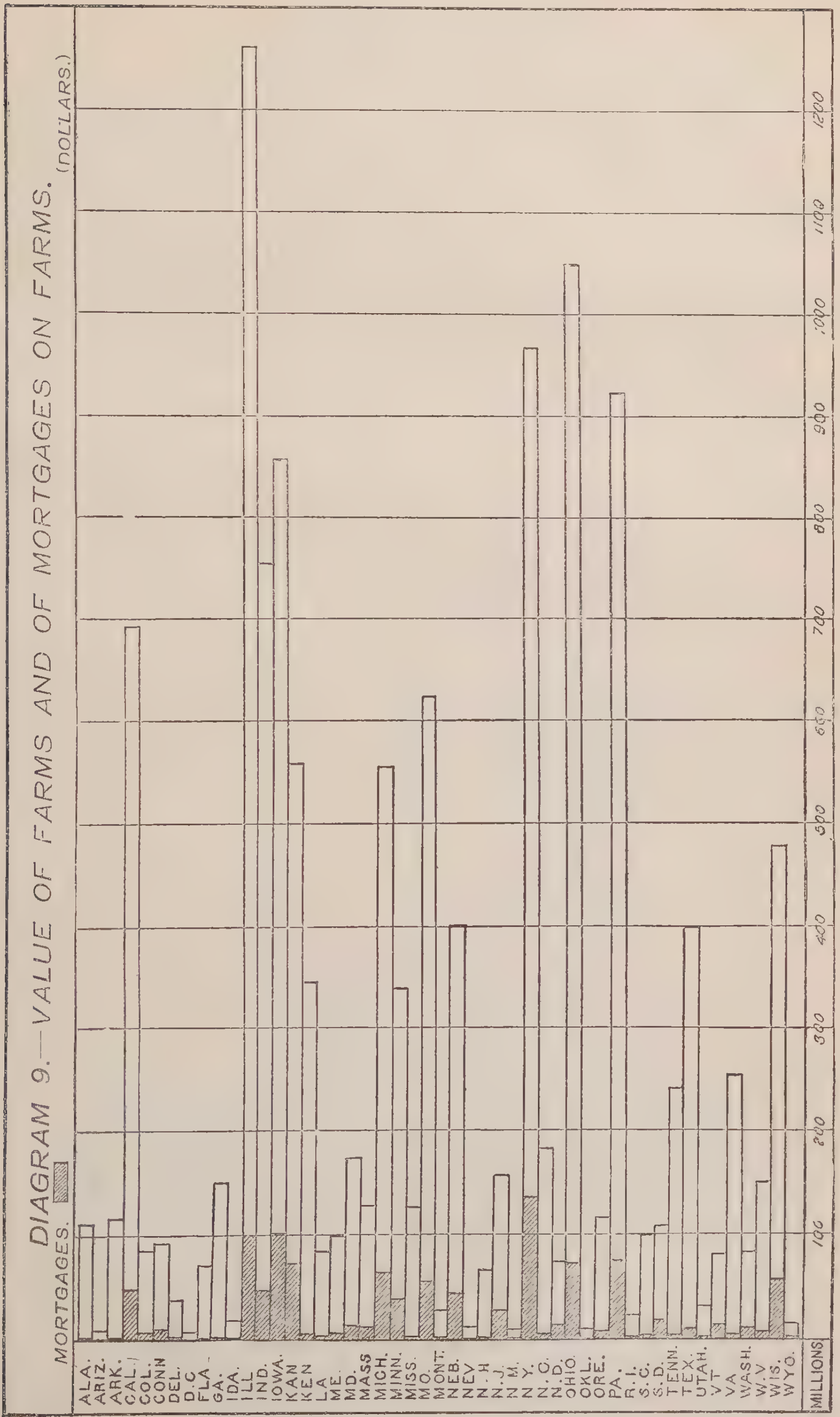


DIAGRAM 9.—VALUE OF FARMS AND OF MORTGAGES ON FARMS. (DOLLARS.)

THE WEATHER BUREAU.

THE WEATHER IN 1896.

Highest and lowest temperatures, with the highest and lowest ever recorded.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Highest and lowest ever recorded.
Boston, Mass	45	56	64	84	94	92	93	95	90	76	72	58	102
	-10	-11	12	25	38	49	57	52	40	33	22	4	-13
Philadelphia, Pa	53	60	63	93	93	91	93	97	92	74	73	60	102
	4	-2	15	28	45	54	61	56	44	37	29	12	-5
Charleston, S. C	64	72	81	89	96	94	98	95	94	85	80	68	104
	27	18	35	44	55	64	70	64	59	50	40	29	10
Jacksonville, Fla	75	79	88	92	95	97	100	96	96	87	85	74	104
	24	27	35	43	53	66	70	64	58	50	45	34	14
Indianapolis, Ind	55	70	68	87	92	94	96	98	92	78	71	61	101
	-5	-5	12	26	52	52	54	50	37	29	10	12	-25
Springfield, Ill	55	70	71	84	90	91	95	98	91	78	74	64	102
	-4	0	14	26	49	54	52	52	39	30	8	9	-22
Davenport, Iowa	52	62	70	83	88	90	94	96	89	72	72	59	100
	-8	-6	9	22	50	50	53	50	36	26	2	8	-27
Des Moines, Iowa	49	70	71	86	87	91	95	94	83	75	74	59	104
	-8	-2	3	20	46	49	54	47	32	26	-2	12	-30
Memphis, Tenn	65	71	78	87	92	92	101	101	96	85	76	73	102
	14	18	27	39	58	58	63	60	41	40	19	21	-8
New Orleans, La	76	73	81	84	92	95	96	96	91	91	84	78	99
	28	37	41	49	65	69	70	70	56	54	35	32	15
Moorhead, Minn	43	59	48	76	88	93	94	94	95	79	32	41	102
	-27	-19	-28	14	36	46	45	34	27	15	-26	-27	-48
Springfield, Mo	64	71	76	85	86	89	95	100	92	83	74	68	102
	4	13	14	28	47	50	57	57	40	33	9	16	-17
Little Rock, Ark	66	73	78	87	93	96	103	105	100	91	78	73	105
	15	24	27	34	57	56	64	60	41	38	21	22	-5
Lincoln, Nebr	63	80	72	91	88	94	95	97	88	80	70	59	......
	-5	6	0	24	44	52	53	49	35	27	0	8	......
Wichita, Kans	66	78	80	89	96	98	99	106	98	90	75	72	106
	4	16	17	24	49	48	60	56	36	34	7	16	-13
Palestine, Tex	73	76	84	85	93	100	97	102	104	92	83	80	104
	20	32	29	38	59	58	67	60	47	45	28	23	-1
Corpus Christi, Tex	79	83	80	82	86	94	90	92	89	83	80	80	98
	34	39	42	53	65	68	72	70	58	56	30	32	16
Helena, Mont	52	60	62	64	75	88	95	92	85	75	63	55	103
	-20	-3	-18	6	29	39	44	42	32	30	-22	6	-42
Denver, Colo	67	68	76	80	86	92	96	94	91	82	75	68	105
	0	9	0	9	32	44	53	43	37	25	-9	18	-29
Walla Walla, Wash	63	69	74	72	84	105	106	96	92	85	71	64	108
	14	28	7	30	36	44	51	53	40	36	-9	10	-17
Sacramento, Cal	62	72	77	72	96	99	104	95	94	92	72	63	108
	28	38	34	36	39	46	51	54	47	44	31	33	19
Los Angeles, Cal	87	88	89	81	103	99	92	91	92	90	84	84	109
	36	36	35	38	44	48	54	54	50	47	37	42	23

Monthly and total annual precipitation in 1896 (in inches and hundredths), with the normal for purposes of comparison.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.	Normal.	Period (years).
Boston, Mass	2.25	3.94	5.41	1.56	1.68	2.71	2.90	2.15	6.40	3.15	3.70	1.70	37.55	44.95	26
Philadelphia, Pa	1.57	6.87	4.11	1.19	2.27	4.07	3.27	.46	2.76	2.08	2.50	1.00	32.15	39.89	25
Charleston, S. C	4.34	4.04	3.61	.71	.52	7.57	10.58	4.72	2.75	1.38	1.77	5.76	47.78	56.74	26
Jacksonville, Fla	2.53	1.66	2.51	.49	1.24	9.41	4.25	6.16	2.19	3.03	4.55	2.17	40.19	52.26	26
Indianapolis, Ind	1.60	2.47	3.08	1.27	3.56	3.09	5.72	3.91	8.17	1.65	4.19	1.13	39.84	43.34	25
Springfield, Ill	1.77	2.11	1.25	1.91	2.49	6.45	8.51	1.87	5.42	1.76	1.88	.31	35.73	38.10	17
Davenport, Iowa	.89	1.45	.84	3.41	4.03	2.28	5.68	3.12	3.98	1.67	.68	.65	28.68	33.80	25
Des Moines, Iowa	.60	.79	1.24	3.47	6.50	2.69	8.15	5.49	3.61	2.69	1.01	.85	37.09	33.34	10
Memphis, Tenn	4.32	3.19	4.78	3.78	2.49	2.07	.80	.84	3.21	1.49	7.47	.56	35.00	53.28	25
New Orleans, La	2.33	2.78	5.29	4.84	2.80	8.23	2.92	3.31	5.26	5.33	2.82	3.77	49.68	60.53	26
Moorhead, Minn	.74	.66	1.48	4.48	4.20	2.61	1.30	2.26	3.02	2.23	3.09	.73	26.80	23.76	16
Springfield, Mo	1.50	2.25	3.40	3.75	11.46	2.81	2.98	3.04	4.12	2.50	2.09	.79	40.89	45.93	10
Little Rock, Ark	4.85	2.89	4.30	2.67	1.32	3.32	.86	1.82	3.85	3.12	3.81	.51	33.32	53.91	17
Lincoln, Nebr	.32	.22	.98	4.57	9.77	2.91	5.33	3.93	5.03	3.30	.79	.29	37.44	......	......
Wichita, Kans	.62	.37	1.58	3.26	3.02	7.10	3.40	.31	3.08	2.27	1.42	.63	27.06	28.61	8
Palestine, Tex	7.67	7.05	1.77	1.22	4.13	.71	1.67	1.19	2.01	7.16	1.67	2.15	38.40	45.94	13
Corpus Christi, Tex	2.41	2.20	.62	1.60	1.94	2.19	2.38	.53	4.39	4.12	.30	.73	23.41	29.13	9
Helena, Mont	.72	.59	1.71	1.23	2.25	.71	.89	.86	2.54	.24	3.29	.35	15.38	13.20	15
Denver, Colo	.25	.24	1.43	.93	1.27	.89	2.80	.97	1.81	.84	.10	.31	11.84	14.50	25
Walla Walla, Wash	1.88	1.20	1.15	3.85	1.68	.88	.15	1.24	.17	1.57	3.09	2.55	19.41	16.81	11
Sacramento, Cal	9.76	.09	2.57	5.34	.92	0	T	.20	.31	.55	3.56	1.76	25.06	21.11	19
Los Angeles, Cal	3.23	T	2.97	.19	.30	T	.02	.01	T	1.30	1.66	2.12	11.80	17.36	19

Mean relative humidity for 1896, with the normal for purposes of comparison.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.	Normal.
Boston, Mass	73	73	71	62	62	70	74	74	79	74	79	68	72	72
Philadelphia, Pa	71	71	64	65	66	68	70	66	72	73	75	68	69	70
Charleston, S. C	85	79	80	79	78	81	81	82	79	78	84	74	80	80
Jacksonville, Fla	82	72	75	72	74	79	80	80	80	79	88	82	78	78
Indianapolis, Ind	80	78	72	60	62	65	68	69	73	68	73	71	70	69
Springfield, Ill	77	72	70	65	71	71	71	70	76	69	75	76	72	71
Davenport, Iowa	78	77	69	63	66	68	67	71	77	67	77	82	72	71
Des Moines, Iowa	74	67	61	63	69	67	70	73	77	68	71	76	70	70
Memphis, Tenn	74	75	83	78	69	71	68	66	66	65	72	75	72	73
New Orleans, La	82	76	80	79	77	78	76	76	79	76	84	78	78	77
Moorhead, Minn	85	82	81	75	72	69	71	64	73	74	86	85	76	77
Springfield, Mo	75	69	72	70	74	77	70	68	74	73	76	70	72	73
Little Rock, Ark	75	72	83	70	68	69	63	61	68	69	74	65	70	73
Wichita, Kans	76	68	69	65	68	66	72	56	68	67	71	67	68	68
Palestine, Tex	75	66	72	72	77	68	71	66	67	76	75	63	71	73
Corpus Christi, Tex	87	79	85	89	86	80	82	83	83	88	87	83	84	82
Helena, Mont	64	63	62	56	58	43	47	45	63	57	66	63	57	55
Denver, Colo	44	46	60	47	44	48	54	45	57	46	40	41	48	49
Walla Walla, Wash	84	76	78	76	74	54	42	45	57	69	79	85	68	61
Sacramento, Cal	81	69	75	73	66	58	58	62	64	50	----	----	----	68
Los Angeles, Cal	71	53	70	67	67	73	79	77	76	77	72	66	71	72

VOLUNTARY OBSERVERS.

For the information of persons who may be contemplating the offer of their services as voluntary observers to the Weather Bureau, the following statement concerning the equipment and duties of a voluntary observer has been prepared by the Chief of the Bureau:

When it is considered that of the more than 3,300 meteorological stations in the United States at which observations are being taken and recorded about 2,900, or nearly 90 per cent, are voluntary, it will be realized to what extent those interested in meteorology are indebted to voluntary observers for the material supplied for scientific research. Without the cooperation of voluntary observers it would be wholly impracticable, with the data collected from the regular telegraphic stations of the Weather Bureau, to determine the local climatic features of the various sections of the country, which is being so thoroughly done through the extensive system of voluntary stations now in existence. The great increase in the number of voluntary meteorological stations during the past decade of years is due to the rapid extension of the State weather-service system, which now embraces the entire country in forty-two State weather-service organizations, which are auxiliaries of the National Weather Bureau in the collection of meteorological data, the distribution of the daily weather forecasts and special warnings, and in the collection and publication of local climatic and weather-crop information through monthly meteorological reports and weekly weather-crop bulletins.

For several years the National Weather Bureau has encouraged the establishment of voluntary meteorological stations by supplying to persons interested in meteorology an instrumental outfit consisting of standard self-registering thermometers and rain gauges, a book of instructions to observers, and suitable blank forms for recording observations, upon condition that one observation shall be taken daily, preferably about sunset or thereafter, and that copies of records of observations made be supplied to the Weather Bureau through the State weather service in whose territory the station is located. Owing to the limited supply of instruments available for distribution to voluntary observers, it has been necessary to impose certain restrictions in their issue in order that the instruments might be placed where observations would prove of the greatest value. It frequently happens that a person offers to cooperate as a volunteer observer and applies for instruments, and then learns through the Weather Bureau that a record is already being kept in his immediate vicinity. In such cases the Weather Bureau is compelled to decline the proffered services as observer as well as to furnish the necessary instruments. Until a few years ago the Weather Bureau in providing instruments for new stations observed the general rule of equipping no station within 50 miles of one already established. With the gradual increase in the number of stations, this distance limit has been reduced to 25 or 30 miles. Persons occupying eligible locations under the rules now governing the issue of instruments, and willing to comply with the conditions upon which they are furnished, will, as far as practicable, be supplied with the instrumental outfit before mentioned upon

application to either the Chief of the Weather Bureau, Washington, D. C., or the director of the State weather service in whose territory he resides.

The duties of a voluntary observer consist in taking and recording daily observations of temperature, rainfall, state of weather, and miscellaneous meteorological phenomena, such as the occurrence of frosts, local storms, etc.

Observations of air pressure and wind velocity by voluntary observers are not desired by the Weather Bureau. Enough data of this nature for the purposes of the Bureau, in the forecasting of weather, are obtained from the regular, paid meteorological stations, from which daily telegraphic reports are received. Observations of air pressure by voluntary observers are mainly of interest to the observers themselves at the time of the observation in estimating the location of storm centers in vicinities where there is no access to the daily weather map issued by the Weather Bureau.

A trustworthy record of the weather is always of interest to any community, and is often of very great practical value. It is one of the objects of the Weather Bureau to foster and encourage the keeping of such records. There are numerous calls for records of the weather as evidence in courts in important law cases months, and even years, after the record is made. Contractors and others interested in outside work often want a record of days when there was rain or there were high winds, when streams were frozen over or swollen with floods, etc. Farmers are interested in the state of the season, whether forward or backward, as regards temperature and rainfall.

The Monthly Weather Review and other publications of the Weather Bureau are sent to voluntary observers in exchange for their observations, together with the weekly Weather Crop Bulletin and monthly reports of State weather services.

TEXTURE OF SOME TYPICAL SOILS.

No.	Locality.	Description.	Organic matter, water, and loss.	Gravel (2-1 mm.).	Coarse sand (1-0.5 mm.).	Medium sand (0.5-0.25 mm.).	Fine sand (0.25-0.1 mm.).	Very fine sand (0.1-0.05 mm.).	Silt (0.05-0.01 mm.).	Fine silt (0.01-0.005 mm.).	Clay (0.005-0.0001 mm.).
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
472	Marley, Md	Truck	0.30	0.49	4.96	40.19	27.59	12.10	7.74	2.23	4.40
141	Davidsonville, Md	Wheat	5.25	.00	.23	1.71	6.08	30.82	20.92	11.21	23.78
937	Hagerstown, Md	Grass	12.88	.00	.08	.13	.53	10.94	19.02	4.67	51.75
16	Lititz, Pa	Cigar wrapper, Habana type.	6.85	.06	.40	.93	3.11	11.45	30.55	10.35	36.30
1254	Poquonock, Conn.	Cigar wrapper, Sumatra type.	2.13	3.22	7.53	19.63	23.76	34.50	5.92	.78	2.53
759	Granville Co., N. C.	Bright tobacco	2.12	3.09	7.16	21.74	22.92	16.76	13.17	8.24	4.80
652	Lynchburg, Va	Shipping tobacco	9.88	.35	1.37	5.72	14.73	10.79	6.70	4.62	45.84
1317	Virginia City, Ill	Upland loess	5.71	.00	.00	.60	.01	7.68	61.85	9.60	15.15
1803	Ogallala, Nebr	Plains marl	2.98	.00	.00	.03	1.95	76.58	12.93	1.31	4.22

NOTE.—The first three samples in the table represent the texture of typical soils of the Atlantic Coast States adapted to truck, wheat, and grass. Their agricultural value and adaptation to crops are largely dependent upon the relative proportion of the different grades of sand and clay, as this determines the relation of the soils to water. Soils differ greatly, however, in structure or in the arrangement of the soil grains, and as this changes their relation to water the texture is not always a guide to their agricultural value. The texture, together with a record of the moisture content, indicates very clearly the class of crops to which these soils are adapted. The same remarks apply to the four types of tobacco soil shown in the table. The loess soils are characterized by a large content of silt. These likewise differ in structure, and this affects their agricultural value. The plains marl of western Kansas and Nebraska is characterized by a large percentage of very fine sand.

The following table gives the weight of a cubic foot of soil under different degrees of compactness, together with the amount of space in these soils, and the per cent of water in the saturated soil when all the space is filled with water:

Per cent by volume of space.	Weight of 1 cubic foot of water-free soil (pounds).	Water in 1 cubic foot of saturated soil (pounds).	Weight of 1 cubic foot of soil, when saturated (pounds).	Per cent by weight of water in saturated soil.
35	107.5	21.8	129.3	16.9
40	99.2	25.0	124.2	20.1
45	90.6	28.1	118.7	22.4
50	82.7	31.2	113.9	27.4
55	74.4	34.3	108.7	31.5
60	66.2	37.4	103.6	36.1
65	58.1	40.6	88.7	41.2

The specific gravity of upland arable soils varies but little and may be assumed to be about 2.65 to 2.70; the former is used by the Department of Agriculture for the mineral constituents of arable soils. The amount of space, therefore, in a cubic foot of such soil is determined by the compactness, or close arrangement, of the soil grains. As a rule, coarse, sandy soils are the most compact and contain the least amount of intergranular space, rarely containing less than 35 per cent of space, however. The amount of space appears larger, as the grains are large and each individual space is larger, but the aggregate amount of space is less. Clay soils usually contain considerably more space than sandy soils, going as high as 60 or 65 per cent in common arable clay lands. The weight of a cubic foot of dry soil in its natural condition is given, approximately, in the second column for several conditions of compactness. The weight of water contained in the soil, if all the space is completely filled with it, is given in the third column. Arable soils in good condition for crops rarely contain more than from 30 to 60 per cent of the saturating quantity. The total weight of a cubic foot of saturated soil and the percentages are given in the fourth and fifth columns.

EDUCATIONAL INSTITUTIONS IN THE UNITED STATES HAVING COURSES IN AGRICULTURE.

State or Territory.	Name of institution.	Location.	President.
Alabama	Agricultural and Mechanical College	Auburn	W. L. Broun.
	State Normal and Industrial School	Normal	W. H. Councill.
Arizona	University of Arizona	Tucson	Howard Billman.
Arkansas	Arkansas Industrial University	Fayetteville	J. L. Buchanan.
California	College of Agr'ture of the University	Berkeley	M. Kellogg.
Colorado	The State Agricultural College	Fort Collins	Alston Ellis.
Connecticut	Storrs Agricultural College	Storrs	B. F. Koons.
Delaware	Delaware College	Newark	G. A. Harter.
	State College for Colored Students	Dover	W. C. Jason.
Florida	State Agricultural and Mech. College	Lake City	O. Clute.
	Florida State Normal School	Tallahassee	T. De S. Tucker.
Georgia	College of Agr'ture and Mech. Arts	Athens	H. C. White.
	State Industrial College	College	R. R. Wright.
Idaho	College of Agr'ture of the University	Moscow	F. B. Gault.
Illinois	College of Agr'ture of the University	Urbana	A. S. Draper.
Indiana	School of Agriculture, Horticulture, and Veterinary Science of Purdue University.	Lafayette	J. H. Smart.
Iowa	College of Agr'ture and Mech. Arts	Ames	W. M. Beardshear.
Kansas	Kansas State Agricultural College	Manhattan	Geo. T. Fairchild.
Kentucky	Agricultural and Mechanical College	Lexington	J. K. Patterson.
	State Normal School	Frankfort	J. H. Jackson.
Louisiana	State University and Agricultural and Mechanical College.	Baton Rouge	T. D. Boyd.
	Southern University and Agricultural and Mechanical College.	New Orleans	H. A. Hill.
Maine	The Maine State College	Orono	A. W. Harris.
Maryland	Maryland Agricultural College	College Park	R. W. Silvester.
Massachusetts	Massachusetts Agricultural College	Amherst	H. H. Goodell.
Michigan	Michigan Agricultural College	Agricultural College.	J. L. Snyder.
Minnesota	College of Agriculture of the Univ	Minneapolis	Cyrus Northrop.
Mississippi	Agricultural and Mechanical College	Agricultural College.	S. D. Lee.
	Alcorn Agr'tural and Mech. College	Westside	E. H. Triplett.
Missouri	College of Agriculture and Mechanic Arts of the University.	Columbia	Richard H. Jesse.
	Lincoln Institute	Jefferson City	I. E. Page.
Montana	College of Agr'ture and Mech. Arts	Bozeman	James Reid.
Nebraska	Industrial College of the University	Lincoln	G. E. MacLean.
Nevada	School of Agriculture of University	Reno	J. E. Stubbs.
New Hampshire	College of Agriculture and the Mechanic Arts.	Durham	C. S. Murkland.
New Jersey	Rutgers Scientific School	New Brunswick	Austin Scott.
New Mexico	College of Agr'ture and Mech. Arts	Mesilla Park	C. T. Jordan.
New York	Cornell University	Ithaca	J. G. Schurman.
North Carolina	College of Agr'ture and Mech. Arts	Raleigh	A. Q. Holladay.
North Dakota	North Dakota Agricultural College	Fargo	J. H. Worst.
Ohio	Ohio State University	Columbus	J. H. Canfield.
Oklahoma	Agricultural and Mechanical College	Stillwater	G. E. Morrow.
Oregon	Oregon State Agricultural College	Corvallis	H. B. Miller.
Pennsylvania	Pennsylvania State College	State College	George W. Atherton.
Rhode Island	College of Agr'ture and Mech. Arts	Kingston	J. H. Washburn.
South Carolina	Clemson Agricultural College	Clemson College	E. B. Craighead.
	College of Agr'ture and Mechanics' Institute of Claflin University.	Orangeburg	L. M. Dunton.
South Dakota	South Dakota Agricultural College	Brookings	J. W. Heston.
Tennessee	State Agr'tural and Mech. College	Knoxville	C. W. Dabney, jr.

EDUCATIONAL INSTITUTIONS IN THE UNITED STATES HAVING COURSES IN AGRICULTURE—Continued.

State or Territory.	Name of institution.	Location.	President.
Texas	State Agr'tural and Mech. College	College Station	L. S. Ross.
	Prairie View State Normal School	Prairie View	L. C. Anderson.
Utah	Agricultural College of Utah	Logan	J. M. Tanner.
Vermont	State Agricultural College of the University.	Burlington	M. H. Buckham.
Virginia	Agr'tural and Mechanical College	Blacksburg	J. M. McBryde.
	Hampton Normal and Agricultural Institute.	Hampton	H. B. Frissell.
Washington	Agric. College and School of Science.	Pullman	E. A. Bryan.
West Virginia	West Virginia University	Morgantown	J. L. Goodknight.
	The West Virginia Colored Institute.	Farm	J. H. Hill.
Wisconsin	College of Agr'ture of the University.	Madison	C. K. Adams.
Wyoming	College of Agr'ture of the University.	Laramie	F. P. Graves.

AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES, THEIR LOCATION, DIRECTORS, AND PRINCIPAL LINES OF WORK.

Station.	Director.	Lines of work in addition to chemistry, horticulture, and field experiments.
Alabama (College), Auburn	W. L. Broun	Botany; fertilizer analysis; diseases of plants; pig feeding.
Alabama (Canebrake), Uniontown.	H. Benton	Diseases of animals.
Arizona, Tucson	W. S. Devol	Entomology; forestry; irrigation.
Arkansas, Fayetteville	R. L. Bennett	Analysis of foods and feeding stuffs; diseases of plants; diseases of animals.
California, Berkeley	E. W. Hilgard	Botany; meteorology; physics and chemistry of soils; composition and cultivation of grapes and orchard fruits (especially olives); chemistry of foods and feeding stuffs; entomology; technology, drainage, and irrigation; reclamation of alkali lands.
Colorado, Fort Collins	Alston Ellis	Meteorology; botany; entomology; irrigation.
Connecticut (State), New Haven	S. W. Johnson	Analysis and inspection of fertilizers and foods; chemistry of feeding stuffs; chemistry of milk and its products; diseases of plants; pot experiments with organic nitrogen.
Connecticut (Storrs), Storrs	W. O. Atwater	Chemistry of feeding stuffs and food of man; digestion experiments; dietary studies; bacteriology of milk and its products; dairying.
Delaware, Newark	A. T. Neale	Diseases of plants; entomology; feeding experiments; dairying; diseases of animals.
Florida, Lake City	O. Clute	Entomology.
Georgia, Experiment	R. J. Redding	Dairying.
Idaho, Moscow	F. B. Gault	Botany; entomology; soils and water; drainage and irrigation.
Illinois, Urbana	E. Davenport	Bacteriology; forestry; diseases of plants; entomology; feeding experiments; dairying.
Indiana, Lafayette	C. S. Plumb	Pot and field experiments; feeding experiments; diseases of animals.
Iowa, Ames	C. F. Curtiss	Diseases of plants; entomology; feeding experiments; dairying.
Kansas, Manhattan	G. T. Fairchild	Diseases of plants; entomology; feeding experiments; diseases of animals; irrigation.
Kentucky, Lexington	M. A. Scovell	Soils; fertilizer analysis; diseases of plants; entomology; dairying.
Louisiana (Sugar), New Orleans	W. C. Stubbs	Bacteriology; soils; sugar making; drainage and irrigation.
Louisiana (State), Baton Rouge	do	Botany; bacteriology; geology; soils; entomology; feeding experiments.
Louisiana (North), Calhoun	do	Soils; feeding experiments; dairying.
Maine, Orono	C. D. Woods	Diseases of plants; food and nutrition of men and animals; diseases of animals; dairying.
Maryland, College Park	R. H. Miller	Soils; entomology; feeding experiments.
Massachusetts, Amherst	H. H. Goodell	Analysis and control of fertilizers; digestion and feeding experiments; meteorology; diseases of plants; entomology; diseases of animals.

AGRICULTURAL EXPERIMENT STATIONS IN THE UNITED STATES, THEIR LOCATION, DIRECTORS, ETC.—Continued.

Station.	Director.	Lines of work in addition to chemistry, horticulture, and field experiments.
Michigan, Agricultural College	C. D. Smith	Botany; bacteriology; forestry; diseases of plants; entomology; feeding experiments; diseases of animals; dairying.
Minnesota, St. Anthony Park	W. M. Liggett	Plant diseases; entomology; feeding and breeding experiments; diseases of animals; dairying.
Mississippi, Agricultural College.	S. M. Tracy	Botany; soils; entomology; digestion and feeding experiments; diseases of animals; drainage and irrigation.
Missouri, Columbia	H. J. Waters	Diseases of plants; entomology; feeding experiments; drainage.
Montana, Bozeman	S. M. Emery	Diseases of plants; feeding experiments; diseases of animals; irrigation.
Nebraska, Lincoln	G. E. MacLean	Botany; meteorology; forestry; feeding and breeding experiments; diseases of animals.
Nevada, Reno	J. E. Stubbs	Botany; soils; entomology; irrigation.
New Hampshire, Durham	C. S. Murkland	Feeding experiments; diseases of animals; dairying.
New Jersey (State), New Brunswick.	E. B. Voorhees	Analysis and control of fertilizers; dairying.
New Jersey (College), New Brunswick.	do	Botany; diseases of plants; entomology; diseases of animals.
New Mexico, Mesilla Park	C. T. Jordan	Botany; diseases of plants; entomology; feeding experiments.
New York (State), Geneva	W. H. Jordan	Meteorology; analysis and control of fertilizers; diseases of plants; feeding experiments; poultry experiments; dairying.
New York (Cornell), Ithaca	I. P. Roberts	Soils; fertilizer investigations; diseases of plants; entomology; feeding experiments; poultry experiments; dairying.
North Carolina, Raleigh	H. B. Battle	Analysis and control of fertilizers; seed testing; composition of feeding stuffs; digestion experiments; poultry experiments.
North Dakota, Fargo	J. H. Worst	Diseases of plants; feeding experiments.
Ohio, Wooster	C. E. Thorne	Soils; diseases of plants; entomology; breeding and feeding experiments.
Oklahoma, Stillwater	G. E. Morrow	Soils and waters; feeding experiments; entomology.
Oregon, Corvallis	H. B. Miller	Soils; diseases of plants; entomology; feeding experiments; dairying.
Pennsylvania, State College	H. P. Armsby	Meteorology; fertilizer analysis; feeding experiments; dairying.
Rhode Island, Kingston	C. O. Flagg	Fertilizer experiments; diseases of plants.
South Carolina, Clemson College	E. B. Craighead	Soils; analysis and control of fertilizers; dairying.
South Dakota, Brookings	J. H. Shepard	Soils; diseases of plants; forestry.
Tennessee, Knoxville	C. F. Vanderford	Botany; entomology.
Texas, College Station	J. H. Connell	Diseases of plants; entomology; feeding experiments; diseases of animals.
Utah, Logan	L. Foster	Feeding experiments; poultry; irrigation.
Vermont, Burlington	J. L. Hills	Analysis and control of fertilizers; diseases of plants; entomology; feeding experiments; diseases of animals; dairying.
Virginia, Blacksburg	J. M. McBryde	Diseases of plants; feeding experiments; diseases of animals; entomology.
Washington, Pullman	E. A. Bryan	Soils; forestry; feeding experiments.
West Virginia, Morgantown	J. A. Myers	Meteorology; analysis and control of fertilizers; entomology.
Wisconsin, Madison	W. A. Henry	Soils; feeding experiments (pigs and sheep); diseases of animals; dairying; drainage and irrigation.
Wyoming, Laramie	F. P. Graves	Geology; botany; waters; soils; entomology; food analyses; feeding experiments; irrigation.

FEEDING STUFFS (FOR ANIMALS).

EXPLANATIONS OF TERMS USED IN THE TABLE.

Water.—All feeding stuffs contain water. The amount varies from 8 to 15 pounds per 100 pounds of such dry materials as hay, straw, or grain to 80 pounds in silage and 90 pounds in some roots.

Ash is what is left when the combustible part of a feeding stuff is burned away. It consists chiefly of lime, magnesia, potash, soda, iron, chlorine, and carbonic,

sulphuric, and phosphoric acids, and is used largely in making bones. Part of the ash constituents of the food is therefore stored up in the animal's body; the rest is voided in the manure.

Protein (or nitrogenous materials) is the name of a group of materials containing nitrogen. Protein furnishes the materials for the lean flesh, blood, skin, muscles, tendons, nerves, hair, horns, wool, and the casein and albumin of milk, etc., and is one of the most important constituents of feeding stuffs.

Fiber.—Fiber, sometimes called cellulose, is the framework of plants, and is, as a rule, the most indigestible constituent of feeding stuffs. The coarse fodders, such as hay and straw, contain a much larger proportion of fiber than the grains, oil cakes, etc.

Nitrogen-free extract includes starch, sugar gums, and the like, and forms an important part of all feeding stuffs, but especially of most grains. The nitrogen-free extract and fiber are usually classed together under the name of carbohydrates. The carbohydrates form the largest part of all vegetable foods. They are either stored up as fat or burned in the body to produce heat and energy.

Fat, or the materials dissolved from a feeding stuff by ether, is an impure product, and includes, besides real fats, wax, the green coloring matter of plants, etc. The fat of food is either stored up in the body as fat or burned to furnish heat and energy.

Average composition of American feeding stuffs.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
GREEN FODDER.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Corn fodder, all varieties	79.3	1.2	1.8	5.0	12.2	0.5
Rye fodder	76.6	1.8	2.6	11.6	6.8	.6
Oat fodder	62.2	2.5	3.4	11.2	19.3	1.4
Redtop (*Agrostis vulgaris*) [1] in bloom	65.3	2.3	2.8	11.0	17.7	.9
Tall oat grass (*Arrhenatherum avenaceum*) [2]	69.5	2.0	2.4	9.4	15.8	.9
Orchard grass (*Dactylis glomerata*)	73.0	2.0	2.6	8.2	13.3	.9
Meadow fescue (*Festuca pratensis*)	69.9	1.8	2.4	10.8	14.3	.8
Italian rye grass (*Lolium italicum*)	73.2	2.5	3.1	6.8	13.3	1.3
Timothy (*Phleum pratense*) [3]	61.6	2.1	3.1	11.8	20.2	1.2
Kentucky blue grass (*Poa pratensis*) [4]	65.1	2.8	4.1	9.1	17.6	1.3
Hungarian grass (*Setaria*)	71.1	1.7	3.1	9.2	14.2	.7
Red clover (*Trifolium pratense*)	70.8	2.1	4.4	8.1	13.5	1.1
Alsike clover (*Trifolium hybridum*) [5]	74.8	2.0	3.9	7.4	11.0	.9
Crimson clover (*Trifolium incarnatum*)	80.9	1.7	3.1	5.2	8.4	.7
Alfalfa (*Medicago sativa*) [6]	71.8	2.7	4.8	7.4	12.3	1.0
Serradella (*Ornithopus sativus*)	79.5	3.2	2.7	5.4	8.6	.7
Cowpea	83.6	1.7	2.4	4.8	7.1	.4
Soja bean (*Soja hispida*)	75.1	2.6	4.0	6.7	10.6	1.0
Horse bean (*Vicia faba*)	84.2	1.2	2.8	4.9	6.5	.4
Flat pea (*Lathyrus sylvestris*)	66.7	2.9	8.7	7.9	12.2	1.6
Rape	84.5	2.0	2.3	2.6	8.4	.5
SILAGE.						
Corn silage	79.1	1.4	1.7	6.0	11.0	0.8
Red-clover silage	72.0	2.6	4.2	8.4	11.6	1.2
Soja-bean silage	74.2	2.8	4.1	9.7	6.9	2.2
Cowpea-vine silage	79.3	2.9	2.7	6.0	7.6	1.5
HAY AND DRY COARSE FODDER.						
Corn fodder, [7] field cured	42.2	2.7	4.5	14.3	34.7	1.6
Corn leaves, field cured	30.0	5.5	6.0	21.4	35.7	1.4
Corn husks, field cured	50.9	1.8	2.5	15.8	28.3	.7
Corn stover, [8] field cured	40.5	3.4	3.8	19.7	31.5	1.1
Hay from—						
Redtop	8.9	5.2	7.9	28.6	47.5	1.9
Orchard grass	9.9	6.0	8.1	32.4	41.0	2.6
Timothy	13.2	4.4	5.9	29.0	45.0	2.5
Kentucky blue grass	21.2	6.3	7.8	23.0	37.8	3.9
Hungarian grass	7.7	6.0	7.5	27.7	49.0	2.1
Meadow fescue	20.0	6.8	7.0	25.9	38.4	2.7
Italian rye grass	8.5	6.9	7.5	30.5	45.0	1.7
Mixed grasses	15.3	5.5	7.4	27.2	42.1	2.5
Rowen (mixed) [9]	16.6	6.8	11.6	22.5	39.4	3.1
Mixed grasses and clovers	12.9	5.5	10.1	27.6	41.3	2.6
Red clover	15.3	6.2	12.3	24.8	38.1	3.3
Alsike clover	9.7	8.3	12.8	25.6	40.7	2.9

[1] Herd's grass of Pennsylvania.
[2] Meadow oat grass.
[3] Herd's grass of New England and New York.
[4] June grass.
[5] Swedish clover.
[6] Lucern.
[7] Entire plant.
[8] What is left after the ears are harvested.
[9] Second cut of hay.

Average composition of American feeding stuffs—Continued.

Feeding stuff.	Water.	Ash.	Protein.	Fiber.	Nitrogen-free extract.	Fat.
HAY AND DRY COARSE FODDER—continued.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Hay from—Continued.						
White clover (*Trifolium repens*)	9.7	8.3	15.7	24.1	39.3	2.9
Crimson clover	9.6	8.6	15.2	27.2	36.6	2.8
Japan clover (*Lespedeza striata*)	11.0	8.5	13.8	24.0	39.0	3.7
Vetch	11.3	7.9	17.0	25.4	36.1	2.3
Serradella	9.2	7.2	15.2	21.6	44.2	6.2
Alfalfa[1]	8.4	7.4	14.3	25.0	42.7	2.2
Cowpea	10.7	7.5	16.6	20.1	42.2	2.9
Soja bean	11.3	7.2	15.4	22.3	38.6	5.2
Flat pea	8.4	7.9	22.9	26.2	31.4	3.2
Peanut vines (without nuts)	7.6	10.8	10.7	23.6	42.7	4.6
Soja-bean straw	10.1	5.8	4.6	40.4	37.4	1.7
Horse-bean straw	9.2	8.7	8.8	37.6	34.3	1.4
Wheat straw	9.6	4.2	3.4	38.1	43.4	1.3
Rye straw	7.1	3.2	3.0	38.9	46.6	1.2
Oat straw	9.2	5.1	4.0	37.0	42.4	2.3
Buckwheat straw	9.9	5.5	5.2	43.0	35.1	1.3
ROOTS AND TUBERS.						
Sugar beets	86.5	.9	1.8	.9	9.8	.1
Mangel-wurzels	90.9	1.1	1.4	.9	5.5	.2
Ruta-bagas	88.6	1.2	1.2	1.3	7.5	.2
Carrots	88.6	1.0	1.1	1.3	7.6	.4
Artichokes	79.5	1.0	2.6	.8	15.9	.2
GRAINS AND OTHER SEEDS.						
Corn kernels	10.9	.5	10.5	2.1	69.6	5.4
Barley	10.9	2.4	12.4	2.7	69.8	1.8
Oats	11.0	3.0	11.8	9.5	59.7	5.0
Rye	11.6	1.9	10.6	1.7	72.5	1.7
Wheat	10.5	1.8	11.9	1.8	71.9	2.1
Sunflower seed (whole)	8.6	2.6	16.3	29.9	21.4	21.2
Cotton seed (whole, with hulls)	9.9	4.7	19.4	22.6	23.9	19.5
Peanut kernels (without hulls)	7.5	2.4	27.9	7.0	15.6	39.6
Horse bean	11.3	3.8	26.6	7.2	50.1	1.0
Soja bean	10.8	4.7	34.0	4.8	28.8	16.9
Cowpea	14.8	3.2	20.8	4.1	55.7	1.4
MILL PRODUCTS.						
Corn meal	15.0	1.4	9.2	1.9	68.7	3.8
Corn and cob meal	15.1	1.5	8.5	6.6	64.8	3.5
Oatmeal	7.9	2.0	14.7	.9	67.4	7.1
Barley meal	11.9	2.6	10.5	6.5	66.3	2.2
Pea meal	10.5	2.6	20.2	14.4	51.1	1.2
WASTE PRODUCTS.						
Oat feed, average	7.7	3.7	16.0	6.1	59.4	7.1
Barley screenings, average	12.2	3.6	12.3	7.3	61.8	2.8
Malt sprouts, average	10.2	5.7	23.2	10.7	48.5	1.7
Brewers' grains (wet)	75.7	1.0	5.4	3.8	12.5	1.6
Brewers' grains (dried)	8.2	3.6	19.9	11.0	51.7	5.6
Rye bran	11.6	3.6	14.7	3.5	63.8	2.8
Wheat bran	11.9	5.8	15.4	9.0	53.9	4.0
Wheat middlings	12.1	3.3	15.6	4.6	60.4	4.0
Wheat shorts	11.8	4.6	14.9	7.4	56.8	4.5
Wheat screenings	11.6	2.9	12.5	4.9	65.1	3.0
Rice bran	9.7	10.0	12.1	9.5	49.9	8.8
Rice hulls	8.2	13.2	3.6	35.7	38.6	.7
Rice polish	10.0	6.7	11.7	6.3	58.0	7.3
Buckwheat middlings	13.2	4.8	28.9	4.1	41.9	7.1
Cotton-seed meal	8.5	7.0	43.3	5.4	22.3	13.5
Cotton-seed hulls	11.4	2.7	4.2	45.3	34.2	2.2
Linseed meal (old process)	9.2	5.7	32.9	8.9	35.4	7.9
Linseed meal (new process)	10.1	5.8	33.2	9.5	38.4	3.0
Peanut meal	10.7	4.9	47.6	5.1	23.7	8.0
Peanut hulls	9.0	3.4	6.6	64.3	15.1	1.6
Hominy chops	11.1	2.5	9.8	3.8	64.5	8.3
Refuse from cornstarch factories.						
Corn germ	10.7	4.0	9.8	4.1	64.0	7.4
Corn-germ meal	8.1	1.3	11.1	9.9	62.5	7.1
Gluten meal:						
Early analyses	8.8	.8	29.7	2.2	49.8	8.7
Recent analyses	8.2	.9	29.3	3.3	46.5	11.8
Chicago	10.1	1.1	30.1	1.6	48.7	8.4
Buffalo	8.2	.8	23.3	6.1	50.4	11.2
Cream gluten	8.1	.7	36.1	1.3	39.0	14.8
Gluten feed	7.8	1.1	24.0	5.3	51.2	10.6
Chicago maize feed	9.1	.9	22.8	7.6	52.7	6.9
Glucose feed and glucose refuse	6.5	1.1	20.7	4.5	56.8	10.4
Dried-starch feed and sugar feed	10.9	.9	19.7	4.7	54.8	9.0
Starch feed (wet)	65.4	.3	6.1	3.1	22.0	3.1

[1] Lucern.

DIGESTIBILITY OF FEEDING STUFFS.

The preceding tables give the total amounts of nutrients found by analysis in different feeding stuffs. Only a portion of these amounts is of direct use to the animal, that is, that digested. The rest passes through the animal and is excreted as manure. The amounts of the different food constituents of feeding stuffs digested have been determined by careful experiments on different classes of animals. The results thus obtained in American experiments have been used in calculating the amounts of digestible protein, fat, and carbohydrates contained in 100 pounds of different feeding stuffs shown in the table below. These are the figures which must be consulted in determining the food value of a given material and in selecting feeding stuffs for making up a ration.

Calorie.—The last column of the table, headed "Fuel value," indicates the value of the food for producing heat for the body and energy for the work. It is stated in calories, a calorie being the amount of heat required to raise the temperature of a pound of water 4° F.

Dry matter and digestible food ingredients in 100 pounds of feeding stuffs.

Feeding stuff.	Dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value.
Green fodder:	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Corn fodder [1]	20.7	1.10	12.08	0.37	26,076
Rye fodder	23.4	2.05	14.11	.44	31,914
Oat fodder	37.8	2.69	22.66	1.04	51,624
Redtop, in bloom	34.7	2.06	21.24	.58	45,785
Orchard grass, in bloom	27.0	1.91	15.91	.58	35,593
Meadow fescue, in bloom	30.1	1.49	16.78	.42	34,755
Timothy	38.4	2.28	23.71	.77	51,591
Kentucky blue grass	34.9	3.01	19.83	.83	45,985
Hungarian grass	28.9	1.92	15.63	.36	34,162
Red clover	29.2	3.07	14.82	.69	36,187
Crimson clover	19.3	2.16	9.31	.44	23,191
Alfalfa	28.2	3.89	11.20	.41	29,798
Cowpea	16.4	1.68	8.08	.25	19,209
Soja bean	28.5	2.79	11.82	.63	29,833
Corn silage	20.9	0.56	11.79	0.65	25,714
Corn fodder, field cured	57.8	2.48	33.38	1.15	71,554
Corn stover, field cured	59.5	1.98	33.16	.57	67,768
Hay from—					
Orchard grass	90.1	4.78	41.99	1.40	92,900
Redtop	91.1	4.82	46.83	.95	100,078
Timothy	86.8	2.89	43.72	1.43	92,729
Kentucky blue grass	78.8	4.76	37.33	1.95	86,516
Hungarian grass	92.3	4.50	51.67	1.34	110,131
Meadow fescue	80.0	4.20	43.34	1.73	95,725
Mixed grasses	87.1	4.22	43.26	1.33	93,925
Rowen (mixed)	83.4	7.19	41.20	1.43	96,040
Mixed grasses and clover	87.1	6.16	42.71	1.46	97,059
Red clover	84.7	6.58	35.35	1.66	84,995
Alsike clover	90.3	8.15	41.70	1.36	98,460
White clover	90.3	11.46	41.82	1.48	105,346
Crimson clover	91.4	10.49	38.13	1.29	95,877
Alfalfa	91.6	10.58	37.33	1.38	94,936
Cowpea	89.3	10.79	38.40	1.51	97,865
Soja bean	88.7	10.78	38.72	1.54	98,568
Wheat straw	90.4	.80	37.94	.46	73,998
Rye straw	92.9	.74	42.71	.35	82,294
Oat straw	90.8	1.58	41.63	.74	83,493
Soja-bean straw	89.9	2.30	39.98	1.03	82,987
Roots and tubers:					
Potatoes	21.1	1.27	15.59		31,360
Beets	13.0	1.21	8.84	.05	18,904
Mangel-wurzels	9.1	1.03	5.65	.11	12,888
Turnips	9.5	.81	6.46	.11	13,986
Ruta-bagas	11.4	.88	7.74	.11	16,497
Carrots	11.4	.81	7.83	.22	16,999
Grains and other seeds:					
Corn (dent and flint)	89.1	7.92	66.69	4.28	156,836
Barley	89.1	8.69	64.83	1.60	143,499
Oats	89.0	9.25	48.34	4.18	124,757
Rye	88.4	9.12	69.73	1.36	152,400
Wheat	89.5	10.23	69.21	1.68	154,848
Cotton seed (whole)	89.7	11.08	33.13	18.44	160,047
Mill products:					
Corn meal	85.0	7.01	65.20	3.25	148,026
Corn and cob meal	84.9	6.46	56.28	2.87	128,808
Oatmeal	92.1	11.53	52.06	5.93	143,302
Barley meal	88.1	7.36	62.88	1.96	138,818

[1] Corn fodder is entire plant, usually sown thick.

Dry matter and digestible food ingredients in 100 pounds of feeding stuffs—Cont'd.

Feeding stuff.	Dry matter.	Protein.	Carbo-hydrates.	Fat.	Fuel value.
Mill products—Continued.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Ground corn and oats, equal parts	88.1	7.39	61.20	3.72	143,276
Pea meal	89.5	16.77	51.78	.65	130,246
Waste products:					
Gluten feed	92.2	20.40	43.75	8.59	155,569
Gluten meal	91.2	25.49	42.32	10.38	169,930
Hominy chops	88.9	7.45	55.24	6.81	145,342
Malt sprouts	89.8	18.72	43.50	1.16	120,624
Brewers' grains (wet)	24.3	4.00	9.37	1.38	30,692
Brewers' grains (dried)	91.1	14.73	36.60	4.82	115,814
Rye bran	88.4	11.45	50.28	1.96	123,089
Wheat bran	88.5	12.01	41.23	2.87	111,138
Wheat middlings	84.0	12.79	53.15	3.40	136,996
Wheat shorts	88.2	12.22	49.98	3.83	131,855
Cotton-seed meal	91.8	37.01	16.52	12.58	152,653
Cotton-seed hulls	88.9	.42	30.95	1.69	65,480
Linseed meal (old process)	90.8	28.76	32.81	7.06	144,313
Linseed meal (new process)	89.8	27.89	36.36	2.73	131,026
Peanut meal	89.3	42.94	22.82	6.86	151,263
Milk and its by-products:					
Whole milk	12.8	3.48	4.77	3.70	30,866
Skim milk—					
Cream raised by setting	9.6	3.13	4.69	.83	18,048
Cream raised by separator	9.4	2.94	5.24	.29	16,439
Buttermilk	9.9	3.87	4.00	1.06	37,685
Whey	6.6	.84	4.74	.31	11,687

FEEDING STANDARDS.

Attempts have been made to ascertain the food requirements of various kinds of farm animals under different conditions. From the results of experiments, feeding standards have been worked out which show the amounts of digestible protein, fat, and carbohydrates supposed to be best adapted to different animals when kept for different purposes. The feeding standards of Wolff, a German, have been most widely used. They are as follows:

Wolff's feeding standards.

A.—PER DAY AND PER 1,000 POUNDS LIVE WEIGHT.

Kind of animal.	Total organic matter.	Digestible food materials.			Fuel value.
		Protein.	Carbohy-drates.	Fat.	
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Oxen at rest in stall	17.5	0.7	8.0	0.15	16,815
Wool sheep, coarser breeds	20.0	1.2	10.3	.20	22,235
Wool sheep, finer breeds	22.5	1.5	11.4	.25	25,050
Oxen moderately worked	24.0	1.6	11.3	.30	24,260
Oxen heavily worked	26.0	2.4	13.2	.50	31,126
Horses moderately worked	22.5	1.8	11.2	.60	26,712
Horses heavily worked	25.5	2.8	13.4	.80	33,508
Milch cows	24.0	2.5	12.5	.40	29,590
Fattening steers:					
First period	27.0	2.5	15.0	.50	34,660
Second period	26.0	3.0	14.8	.70	36,062
Third period	25.0	2.7	14.8	.60	35,082
Fattening sheep:					
First period	26.0	3.0	15.2	.50	35,962
Second period	25.0	3.5	14.4	.60	35,826
Fattening swine:					
First period	36.0	5.0	27.5		60,450
Second period	31.0	4.0	24.0		52,080
Third period	23.5	2.7	17.5		37,570

Wolff's feeding standards—Continued.

B.—PER DAY AND PER HEAD.

Kind of animal.	Average live weight per head.	Total organic matter.	Digestible food materials.			Fuel value.
			Protein.	Carbohydrates.	Fat.	
Growing cattle:						
Age—	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
2 to 3 months	150	3.3	0.6	2.1	0.30	5,116
3 to 6 months	300	7.0	1.0	4.1	.30	10,750
6 to 12 months	500	12.0	1.3	6.8	.30	16,332
12 to 18 months	700	16.8	1.4	9.1	.28	20,712
18 to 24 months	850	20.4	1.4	10.3	.26	22,859
Growing sheep:						
Age—						
5 to 6 months	56	1.6	.18	.87	.045	2,143
6 to 8 months	67	1.7	.17	.85	.040	2,066
8 to 11 months	75	1.7	.16	.85	.037	2,035
11 to 15 months	82	1.8	.14	.89	.032	2,051
15 to 20 months	85	1.9	.12	.88	.025	1,966
Growing fat swine:						
Age—						
2 to 3 months	50	2.1	.38	1.50		3,496
3 to 5 months	100	3.4	.50	2.50		5,580
5 to 6 months	125	3.9	.54	2.96		6,510
6 to 8 months	170	4.6	.58	3.47		7,533
8 to 12 months	250	5.2	.62	4.05		8,686

CALCULATION OF RATIONS.

In order to explain the use of the preceding tables, let us calculate the daily ration for a cow, assuming that the farmer has on hand clover hay, corn silage, corn meal, and wheat bran. Wolff's standard for a cow of 1,000 pounds calls for 2.5 pounds of protein, 12.5 pounds of carbohydrates, and 0.4 pound of fat, which would furnish 29,590 calories of heat. From the table showing the amounts of digestible nutrients we find that 100 pounds of clover hay furnishes 84.7 pounds of dry matter, 6.58 pounds of protein, 35.35 pounds of carbohydrates, and 1.66 pounds of fat, equivalent to a fuel value of 84,995 calories. Twelve pounds would have 10.16 pounds of dry matter, containing 0.79 pound of protein, 4.24 pounds of carbohydrates, and 0.20 pound of fat, and giving a fuel value of 10,199 calories. In the same way the amounts furnished by 20 pounds of corn silage, 4 pounds of corn meal, and 4 pounds of wheat bran are found. The results would be as given in the following table:

Method of calculating ration for dairy cow.

Ration.	Total dry matter.	Digestible protein.	Digestible carbohydrates.	Digestible fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
12 pounds of clover hay	10.16	0.79	4.24	0.20	10,199
20 pounds of corn silage	4.18	.11	2.36	.13	5,143
4 pounds of corn meal	3.40	.28	2.61	.13	5,921
4 pounds of wheat bran	3.54	.48	1.65	.11	4,446
Total	21.28	1.66	10.86	.57	25,709
Wolff's standard	24.00	2.50	12.50	.40	29,590

This ration is below the standard, especially in protein. To furnish the protein needed without increasing the other nutrients too much, a feeding stuff quite rich in protein is needed. The addition of 4 pounds of gluten feed would make the ration as shown in the following table:

Completed ration for dairy cow.

Ration.	Total dry matter.	Digestible protein.	Digestible carbohydrates.	Digestible fat.	Fuel value.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
12 pounds clover hay, 20 pounds corn silage, 4 pounds corn meal, and 4 pounds wheat bran	21.28	1.66	10.86	0.57	25,709
4 pounds gluten feed	3.69	.82	1.75	.34	6,223
Total	24.97	2.48	12.61	.91	31,932

This ration, it will be seen, contains somewhat more carbohydrates and fat than the standard calls for, but is close enough to the standard for practical purposes. The calculation may be considerably simplified, without impairing accuracy, by considering only the protein and the fuel value. For example, suppose the farmer feeds his cows dry corn fodder (not stover), good timothy hay (herd's grass), and a grain mixture composed of equal parts of corn meal, wheat bran, and gluten meal, a ration might be made from these as follows:

Ration per cow daily.

Ration.	Dry matter.	Protein.	Fuel value.
	Pounds.	*Pounds.*	*Calories.*
10 pounds timothy hay	8.68	0.30	9,273
10 pounds dry corn fodder	5.78	.25	7,155
4 pounds corn meal	3.40	.28	5,921
4 pounds wheat bran	3.54	.48	4,446
4 pounds gluten meal	3.62	1.02	6,797
Total	25.02	2.33	33,592

This ration is higher than the standard in fuel value, owing to richness of the materials in carbohydrates and fat, and slightly lower in protein. The substitution of 1 pound of new-process linseed meal in place of 1 pound of the corn meal would give 0.21 pound more protein, which would make the ration contain 2.54 pounds of protein.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
GREEN FODDERS.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Corn fodder	78.61	4.84	0.41	0.15	0.33
Sorghum fodder	82.19		.23	.09	.23
Rye fodder	62.11		.33	.15	.73
Oat fodder	83.36	1.31	.49	.13	.38
Common millet	62.58		.61	.19	.41
Japanese millet	71.05		.53	.20	.34
Hungarian grass (*Setaria*)	74.31		.39	.16	.55
Orchard grass (*Dactylis glomerata*) [1]	73.14	2.09	.43	.16	.76
Timothy grass (*Phleum pratense*) [1]	66.90	2.15	.48	.26	.76
Perennial rye grass (*Lolium perenne*) [1]	75.20	2.60	.47	.28	1.10
Italian rye grass (*Lolium italicum*) [1]	74.85	2.84	.54	.29	1.14
Mixed pasture grasses	63.12	3.27	.91	.23	.75
Red clover (*Trifolium pratense*)	80.00		.53	.13	.46
White clover (*Trifolium repens*)	81.60		.56	.20	.24
Alsike clover (*Trifolium hybridum*)	81.80	1.47	.44	.11	.20
Crimson clover (*Trifolium incarnatum*)	82.50		.43	.13	.49
Alfalfa (*Medicago sativa*)	75.30	2.25	.72	.13	.56
Cowpea	78.81	1.47	.27	.10	.31
Serradella (*Ornithopus sativus*)	82.59	1.82	.41	.14	.42
Soja bean (*Soja hispida*)	73.20		.29	.15	.53
Horse bean (*Vicia faba*)	74.71		.68	.33	1.37
White lupine (*Lupinus albus*)	85.35		.44	.35	1.73
Yellow lupine (*Lupinus luteus*) [1]	83.15	.96	.51	.11	.15
Flat pea (*Lathyrus sylvestris*) [1]	71.60	1.93	1.13	.18	.58
Common vetch (*Vicia sativa*) [1]	84.50	1.94	.59	1.19	.70
Prickly comfrey (*Symphytum asperrimum*)	84.36	2.45	.42	.11	.75
Corn silage	77.95		.28	.11	.37
Apple pomace silage [1]	75.00	1.05	.32	.15	.40
HAY AND DRY COARSE FODDERS.					
Corn fodder (with ears)	7.85	4.91	1.76	.54	.89
Corn stover (without ears)	9.12	3.74	1.04	.29	1.40
Teosinte (*Euchlæna luxurians*)	6.06	6.53	1.46	.55	3.70
Common millet	9.75		1.28	.49	1.69
Japanese millet	10.45	5.80	1.11	.40	1.22
Hungarian grass	7.69	6.18	1.20	.35	1.30
Hay of mixed grasses	11.99	6.34	1.41	.27	1.55
Rowen of mixed grasses	18.52	9.57	1.61	.43	1.49
Redtop (*Agrostis vulgaris*)	7.71	4.59	1.15	.36	1.02
Timothy	7.52	4.93	1.26	.53	.90
Orchard grass	8.84	6.42	1.31	.41	1.88

[1] Dietrich and König: Zusammensetzung und Verdaulichkeit der Futtermittel.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS—Continued.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
HAY AND DRY COARSE FODDERS—continued.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Kentucky blue grass (*Poa pratensis*)	10.35	4.16	1.19	0.40	1.57
Meadow fescue (*Festuca pratensis*)	8.89	8.08	.99	.40	2.10
Tall meadow oat grass (*Arrhenatherum avenaceum*)	15.35	4.92	1.16	.32	1.72
Meadow foxtail (*Alopecurus pratensis*)	15.35	5.24	1.54	.44	1.99
Perennial rye grass	9.13	6.79	1.23	.56	1.55
Italian rye grass	8.71		1.19	.56	1.27
Japanese buckwheat	5.72		1.63	.85	3.32
Red clover	11.33	6.93	2.07	.38	2.20
Mammoth red clover (*Trifolium medium*)	11.41	8.72	2.23	.55	1.22
White clover			2.75	.52	1.81
Crimson clover [1]	18.30	7.70	2.05	.40	1.31
Alsike clover	9.94	11.11	2.34	.67	2.23
Alfalfa	6.55	7.07	2.19	.51	1.68
Blue melilot (*Melilotus cœruleus*)	8.22	13.65	1.92	.54	2.80
Bokhara clover (*Melilotus alba*)	7.43	7.70	1.98	.56	1.83
Sainfoin (*Onobrychis sativa*)	12.17	7.55	2.63	.76	2.02
Sulla (*Hedysarum coronarium*)	9.39		2.46	.45	2.09
Lotus villosus	11.52	8.23	2.10	.59	1.81
Soja bean (whole plant)	6.30	6.47	2.32	.67	1.08
Soja bean (straw)	13.00		1.75	.40	1.32
Cowpea (whole plant)	10.95	8.40	1.95	.52	1.47
Serradella	7.39	10.60	2.70	.78	.65
Cotton (whole plant)	7.36	5.81	1.46	.44	1.32
Oxeye daisy (*Chrysanthemum leucanthemum*)	9.65	6.37	.28	.44	1.25
Dry carrot tops	9.76	12.52	3.13	.61	4.88
Barley straw	11.44	5.30	1.31	.30	2.09
Barley chaff	13.08		1.01	.27	.99
Wheat straw	12.56	3.81	.59	.12	.51
Wheat chaff	8.05	7.18	.79	.70	.42
Rye straw	7.61	3.25	.46	.28	.79
Oat straw	9.09	4.76	.62	.20	1.24
Buckwheat hulls	11.90		.49	.07	.52
ROOTS, BULBS, TUBERS, ETC.					
Potatoes	79.24	.89	.32	.12	.46
Red beets	87.73	1.13	.24	.09	.44
Yellow fodder beets	90.60	.95	.19	.09	.46
Sugar beets	86.95	1.04	.22	.10	.48
Mangel-wurzels	87.29	1.22	.19	.09	.38
Turnips	89.49	1.01	.18	.10	.39
Ruta-bagas	89.13	1.06	.19	.12	.49
Carrots	89.79	9.22	.15	.09	.51
GRAINS AND OTHER SEEDS.					
Corn kernels	10.88	1.53	1.82	.70	.40
Sorghum seed	14.00		1.48	.81	.42
Barley [1]	14.30	2.48	1.51	.79	.48
Oats	18.17	2.98	2.06	.82	.62
Wheat (spring)	14.35	1.57	2.36	.70	.39
Wheat (winter)	14.75		2.36	.89	.61
Rye	14.90		1.76	.82	.54
Common millet	12.68		2.04	.85	.36
Japanese millet	13.68		1.73	.69	.38
Rice	12.60	.82	1.08	.18	.09
Buckwheat	14.10		1.44	.44	.21
Soja beans	18.33	4.99	5.30	1.87	1.99
Cotton seed	8.42	3.78	3.13	1.27	1.17
MILL PRODUCTS.					
Corn meal	12.95	1.41	1.58	.63	.40
Corn and cob meal	8.96		1.41	.57	.47
Ground oats	11.17	3.37	1.86	.77	.59
Ground barley	13.43	2.06	1.55	.66	.34
Rye flour	14.20		1.68	.85	.65
Wheat flour	9.83	1.22	2.21	.57	.54
Pea meal	8.85	2.68	3.08	.82	.99
BY-PRODUCTS AND WASTE MATERIALS.					
Corncobs	12.09	.82	.50	.06	.60
Hominy feed	8.93	2.21	1.63	.98	.49
Gluten meal	8.59	.73	5.03	.33	.05
Starch feed (glucose refuse)	8.10		2.62	.29	.15

[1] Dietrich and König.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS—Continued.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
BY-PRODUCTS AND WASTE MATERIALS—cont'd.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Malt sprouts	18.38	12.48	3.55	1.43	1.63
Brewers' grains (dry)	9.14	3.92	3.62	1.03	.09
Brewers' grains (wet)	75.01	----------	.89	.31	.05
Rye bran	12.50	4.60	2.32	2.28	1.40
Rye middlings[1]	12.54	3.52	1.84	1.26	.81
Wheat bran	11.74	6.25	2.67	2.89	1.61
Wheat middlings	9.18	2.30	2.63	.95	.63
Rice bran	10.20	12.94	.71	.29	.24
Rice polish	10.30	9.00	1.97	2.67	.71
Cotton-seed meal	7.81	6.95	6.79	2.88	.87
Cotton-seed hulls	10.17	2.40	.69	.25	1.02
Linseed meal (old process)	8.88	6.08	5.43	1.66	1.37
Linseed meal (new process)	7.77	5.37	5.78	1.83	1.39
Peanut-cake meal	10.40	3.97	7.56	1.31	1.50
Apple pomace	80.50	.27	.23	.02	.13
VEGETABLES.					
Artichokes	81.50	.99	.36	.17	.48
Asparagus stems	93.96	.67	.29	.08	.29
Beans, adzuki	15.86	3.53	3.29	.95	1.51
Beets, red	88.47	1.04	.24	[2] .09	[2] .44
Cabbages	90.52	1.40	.38	[2] .11	[2] .43
Carrots	88.59	1.02	.16	.09	.51
Cauliflower	90.82	.81	.13	.16	.36
Chorogi tubers	78.90	1.09	1.92	.19	.64
Cucumbers	95.99	.46	.16	.12	.24
Horse-radish root	76.68	1.87	.36	.07	1.16
Kohl-rabi	91.08	1.27	.48	.27	.43
Lettuce, whole plant	93.68	1.61	.23	[2] .07	[2] .37
Onions	87.55	.57	.14	.04	.10
Parsnips	80.34	1.03	.22	.19	.62
Peas:					
Garden	12.62	3.11	3.58	.84	1.01
Small (*Lathyrus sativus*), whole plant	5.80	5.94	2.50	.59	1.99
Pumpkins, whole fruit	92.27	.63	[2] .11	[2] .16	[2] .09
Rhubarb:					
Roots	74.35	2.28	.55	.06	.53
Stems and leaves	91.67	1.72	.13	.02	.36
Ruta-bagas	88.61	1.15	.19	.12	.49
Spinach	92.42	1.94	.49	.16	.27
Sweet corn:					
Cobs	80.10	.59	.21	.05	.22
Husks	86.19	.56	.18	.07	.22
Kernels	82.14	.56	.46	.07	.24
Stalks	80.86	1.25	.28	.14	.41
Sweet potatoes:					
Tubers	72.96	.95	.23	.10	.50
Vines	83.06	2.45	.42	.07	.73
Tomatoes:					
Fruits	93.64	.47	.16	.05	.27
Roots	73.31	11.72	.24	.06	.29
Vines	83.61	3.00	.32	.07	.50
Turnips	90.46	.80	.18	.10	.39
FRUITS AND NUTS.					
Apple leaves:					
Collected in May	72.36	2.33	.74	.25	.25
Collected in September	60.71	3.46	.89	.19	.39
Apples, fruit	85.30	.39	.13	.01	.19
Apple trees (young):					
Branches	83.60	.65	----------	.04	.04
Roots	64.70	1.59	----------	.11	.09
Trunks	51.70	1.17	----------	.06	.06
Whole plant	60.83	----------	.35	.05	.17
Apricots, fresh	85.16	.49	.19	.06	.29
Blackberries	88.91	.58	.15	.09	.20
Blueberries	82.69	.16	.14	.05	.05
Cherries, fruit	86.10	.58	.18	[1] .06	[1] .20
Cherry trees (young):					
Branches	79.50	.78	----------	.05	.06
Roots	67.20	1.22	----------	.08	.07
Trunks	53.20	.81	----------	.04	.06
China berries	16.52	4.13	1.19	.43	2.33
Cranberries:					
Fruit	89.59	.18	----------	.03	.09
Vines	----------	2.45	----------	.27	.32

[1] Dietrich and König. [2] Wolff.

FERTILIZING CONSTITUENTS OF FEEDING STUFFS AND FARM PRODUCTS—Continued.

Material.	Water.	Ash.	Nitrogen.	Phosphoric acid.	Potash.
FRUITS AND NUTS—continued.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Currants	86.02	0.53	----------	0.11	0.27
Grapes, fruits, fresh	83.00	.50	0.16	.09	.27
Grapes, wood of vine	----------	2.97	----------	.42	.67
Lemons	83.83	.56	.15	.06	.27
Nectarines	79.00	.50	.12	----------	----------
Olives:					
Fruit	58.00	1.42	.18	.12	.86
Leaves	42.40	2.51	.91	.26	.76
Wood of larger branches	14.50	.94	.88	.11	.18
Wood of small branches	18.75	.96	.89	.12	.20
Oranges:					
California	85.21	.43	.19	.05	.21
Florida	87.71	----------	.12	.08	.48
Peaches:					
Fruit	87.85	.32	----------	.05	.24
Wood of branches	58.26	1.93	.90	.22	.50
Pears, fruit	83.92	.54	.09	.03	.08
Pear trees (young):					
Branches	84.00	.76	----------	.04	.08
Roots	66.70	1.40	----------	.07	.11
Trunks	49.30	1.71	----------	.07	.13
Plums	47.43	.54	.18	.02	.24
Prunes	77.33	.49	.16	.07	.31
Raspberries	81.82	.55	.15	.48	.35
Strawberries:					
Fruit	90.84	.60	.15	.11	.30
Vines	----------	3.34	----------	.48	.35
Chestnuts, native	40.00	1.62	1.18	.39	.63
Peanuts:					
Hulls	10.60	3.00	1.14	.17	.95
Kernels	6.30	3.20	4.51	1.24	1.27
Vines (cured)	7.83	15.70	1.76	.29	.98
DAIRY PRODUCTS.					
Whole milk	87.00	.75	.53	.19	.18
Skim milk	90.25	.80	.56	.20	.19
Cream	74.05	.50	.40	.15	.13
Buttermilk	90.50	.70	.48	.17	.16
Whey	92.97	.60	.15	.14	.18
Butter	79.10	.15	.12	.04	.04
Cheese	33.25	2.10	3.93	.60	.12
WOODS.					
Ash, wood	10.00	.32	----------	.012	.149
Chestnut:					
Bark	10.00	3.51	----------	.114	.278
Wood	10.00	.16	----------	.011	.029
Dogwood:					
Bark	10.00	9.87	----------	.140	.341
Wood	10.00	.68	----------	.057	.190
Hickory:					
Bark	10.00	3.97	----------	.061	.141
Wood	10.00	.48	----------	.058	.138
Magnolia:					
Bark	10.00	2.98	----------	.095	.192
Wood	10.00	.36	----------	.032	.071
Maple, bark	10.00	9.49	----------	.421	1.197
Oak:					
Leaves, mixed	----------	4.70	----------	----------	----------
Post, bark	10.00	12.10	----------	.116	.249
Post, wood	10.00	.77	----------	.070	.169
Red, bark	10.00	6.29	----------	.103	.179
Red, wood	10.00	.57	----------	.060	.140
White, bark	10.00	5.95	----------	.074	.125
White, wood	10.00	.26	----------	.025	.106
Pine:					
Burr	----------	1.09	----------	----------	----------
Georgia, bark	10.00	.37	----------	.013	.024
Georgia, wood	10.00	.33	----------	.012	.050
Old field, bark	10.00	1.94	----------	.095	.077
Old field, wood	10.00	.18	----------	.007	.008
Straw, mixed	----------	1.65	----------	----------	----------
Yellow, wood	10.00	.23	----------	.010	.045
Black, wood	10.00	.21	----------	.009	.030
Sycamore, wood	10.00	.99	----------	.121	.230

FERTILIZING CONSTITUENTS CONTAINED IN A CROP OF COTTON YIELDING 100 POUNDS OF LINT PER ACRE.

[Pounds per acre.]

Material.	Nitrogen.	Phosphoric acid.	Potash.	Lime.	Magnesia.
Roots (83 pounds)	0.76	0.43	1.06	0.53	0.34
Stems (219 pounds)	3.20	1.29	3.09	2.12	.92
Leaves (192 pounds)	6.16	2.28	3.46	8.52	1.67
Bolls (135 pounds)	3.43	1.30	2.44	.69	.54
Seed (218 pounds)	6.82	2.77	2.55	.55	1.20
Lint (100 pounds)	.34	.10	.46	.19	.03
Total crop (847 pounds)	20.71	8.17	13.06	12.60	4.75

ANALYSES OF FERTILIZERS.

Material.	Nitrogen.	Available phosphoric acid.	Insoluble phosphoric acid.	Total phosphoric acid.	Potash.	Chlorine.
COMMERCIAL FERTILIZERS.						
1. Supplying nitrogen:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Nitrate of soda	15.5 to 16					
Sulphate of ammonia	19 to 20.5					
Dried blood (high grade)	12 to 14					
Dried blood (low grade)	10 to 11			3 to 5		
Concentrated tankage	11 to 12.5			1 to 2		
Tankage (bone)	5 to 6			11 to 14		
Dried fish scrap	7 to 9			6 to 8		
Cotton-seed meal	6.5 to 7.5			1.5 to 2	2 to 3	
Castor pomace	5 to 6			1 to 1.5	1 to 1.5	
2. Supplying phosphoric acid:						
South Carolina rock phosphate			26 to 28	26 to 28		
South Carolina rock superphosphate (dissolved South Carolina rock phosphate)		12 to 15	1 to 3	13 to 16		
Florida land rock phosphate			33 to 35	33 to 35		
Florida pebble phosphate			26 to 32	26 to 32		
Florida superphosphate (dissolved Florida phosphate)		14 to 16	1 to 4	16 to 20		
Boneblack			32 to 36	32 to 36		
Boneblack superphosphate (dissolved boneblack)		15 to 17	1 to 2	17 to 18		
Ground bone	2.5 to 4.5	5 to 8	15 to 17	20 to 25		
Steamed bone	1.5 to 2.5	6 to 9	16 to 20	22 to 29		
Dissolved bone	2 to 3	13 to 15	2 to 3	15 to 17		
Thomas slag				[1] 11.4 to 23		
3. Supplying potash:						
Muriate of potash					50	45 to 48
Sulphate of potash (high grade)					48 to 52	.5 to 1.5
Sulphate of potash and magnesia					26 to 30	1.5 to 2.5
Kainite					12 to 12.5	30 to 32
Sylvinite					16 to 20	42 to 46
Cotton-hull ashes [2]				7 to 9	20 to 30	
Wood ashes (unleached) [2]				1 to 2	2 to 8	
Wood ashes (leached) [2]				1 to 1.5	1 to 2	
Tobacco stems	2 to 3			3 to 5	5 to 8	
FARM MANURES.						
Cattle excrement (solid, fresh)	.29			.17	.10	
Cattle urine (fresh)	.58				.49	
Hen manure (fresh)	1.10			.85	.56	
Horse excrement (solid)	.44			.17	.35	
Horse urine (fresh)	1.55				1.50	
Human excrement (solid)	1.00			1.09	.25	
Human urine	.60			.17	.20	
Pigeon manure (dry)	3.20			1.90	1.00	
Sheep excrement (solid, fresh)	.55			.31	.15	
Sheep urine (fresh)	1.95			.01	2.26	
Swine excrement (solid, fresh)	.60			.41	.13	
Swine urine (fresh)	.43			.07	.83	
Barnyard manure (average)	.49			.32	.43	

[1] In good Thomas slag at least 80 per cent of the phosphoric acid should be soluble in ammonium citrate, that is, available.

[2] Cotton-hull ashes contain about 10 per cent of lime, unleached wood ashes 30 to 35 per cent, and leached wood ashes 35 to 40 per cent.

BARNYARD MANURE.

Barnyard manure contains all the fertilizing elements required by plants in forms that insure plentiful crops and permanent fertility to the soil. It not only enriches the soil with the nitrogen, phosphoric acid, and potash, which it contains, but it also renders the stored-up materials of the soil more available, improves the mechanical condition of the soil, makes it warmer, and enables it to retain more moisture or to draw it up from below.

On the basis of the prices charged for commercial fertilizers, the fertilizing value of the manure produced by the farm animals of the United States last year was upward of $2,000,000,000. The average of each horse is estimated at $27, for each head of cattle $19, for each hog $12, and for each sheep $2.

Amount and value of manure produced by different farm animals.

[New York Cornell Experiment Station.]

Animal.	Per 1,000 pounds of live weight.			Value of manure per ton.
	Amount per day.	Value per day.[1]	Value per year.[1]	
	Pounds.	*Cents.*		
Sheep	34.1	7.2	$26.09	$3.30
Calves	67.8	6.2	24.45	2.18
Pigs	83.6	16.7	60.88	3.29
Cows	74.1	8.0	29.27	2.02
Horses	48.8	7.6	27.74	2.21

[1] Valuing nitrogen at 15 cents, phosphoric acid at 6 cents, and potash at 4½ cents per pound.

Barnyard manure is a very variable substance, its composition and value depending principally upon (1) age and kind of animal; (2) quantity and quality of food; (3) proportion of litter; and, (4) method of management and age of manure.

Mature animals, neither gaining nor losing weight, excrete practically all the fertilizing constituents consumed in the food. Growing animals and milch cows excrete from 50 to 75 per cent of the fertilizing constituents of the food; fattening or working animals from 90 to 95 per cent. As regards the fertilizing value of equal weights of manure in its normal condition, farm animals probably stand in the following order: Poultry, sheep, pigs, horses, cows.

The amounts of fertilizing constituents in the manure stand in direct relation to those in the food. As regards the value of manure produced, the concentrated feeding stuffs, such as meat scrap, cotton-seed meal, linseed meal, and wheat bran, stand first, the leguminous plants (clover, peas, etc.) second, the grasses third, cereals (oats, corn, etc.) fourth, and root crops, such as turnips, beets, and mangel-wurzels, last.

Barnyard manure is a material which rapidly undergoes change. When it is practical to haul the manure from the stalls and pen and spread it on the field at frequent intervals the losses of valuable constituents need not be very great, but when (as in winter) the manure must be stored for some time the difficulties of preservation become greatly increased.

The deterioration of manure results from two chief causes: (1) fermentation and (2) weathering or leaching. The loss from destructive fermentation may be almost entirely prevented by the use of proper absorbents and preservatives, such as superphosphate and kainite, and especially by keeping the manure moist and excluding the air.

Amounts of different preservatives to be used per head daily.

Preservative.	Per horse, 1,000 pounds' weight.		Per cow, 880 pounds' weight.		Per pig, 220 pounds' weight.	Per sheep, 110 pounds' weight.
	Lbs.	*Ozs.*	*Lbs.*	*Ozs.*	*Ounces.*	*Ounces.*
Superphosphate	1	0	1	2	3	$2\frac{1}{3}$
Gypsum	1	9	1	12	$4\frac{3}{5}$	$3\frac{3}{5}$
Kainite	1	2	1	5	4	$3\frac{1}{5}$

If kainite is used it should be applied to the fresh manure and covered with litter so that it does not come in contact with the feet of the animals. All preservatives are more effective if applied before decomposition sets in.

Loss from leaching may be prevented by storage under cover or in pits. Extremes of moisture and temperature are to be avoided, and uniform and moderate fermentation is the object to be sought. To this end, it is advisable to mix the manure from the different animals thoroughly in the heap, and keep the mass compact.

Barnyard manure is justly held in high esteem as a general fertilizer, but it has a forcing effect when fresh, and is therefore better suited to grasses and forage plants than to plants grown for seed, such as cereals. Direct applications, especially to root crops, such as sugar beets, potatoes, or tobacco, often prove injurious. This result can, as a rule, be avoided by applying the manure some months before the planting of the crop or by using only well-rotted manure.

Barnyard manure is not applied to fruit trees with the same good results that attend its use in the case of field crops, garden truck, etc. It does not stimulate fruiting to the same extent as do the mineral fertilizers. Its tendency is to produce a large growth, but a poor quality, of fruit. Oranges, in particular, become coarse, thick skinned, and sour under its influence.

As a rule, the best results are likely to be obtained by using commercial fertilizing materials in connection with barnyard manure, either in compost or separately.

METHODS OF CONTROLLING INJURIOUS INSECTS.

[The species marked with an asterisk (*) have gained entrance into America from foreign countries and represent twenty-eight out of the sixty-three species listed. The origin of those preceded with an interrogation point is in doubt.]

REMEDIES FOR IMPORTANT INSECTS.

*ANGOUMOIS GRAIN MOTH (*Sitotroga cerealella* Oliv.). Prompt thrashing of grain after harvesting; bisulphide of carbon in bins and granaries; storage in bulk.

APPLE-LEAF SKELETONIZER (*Canarsia hammondi* Riley). Spraying with arsenicals (paris green and london purple) in June; hand picking of leaves with larvæ.

?APPLE-ROOT PLANT LOUSE (*Schizoneura lanigera* Hausm.). Kerosene emulsion under and above ground; scalding water poured freely about roots; bisulphide of carbon under ground about roots; powdered tobacco or ashes incorporated in the soil,

APPLE-TREE BORER, FLAT-HEADED (*Chrysobothris femorata* Fab.). Painting trunk and larger branches in June with strong soap solution, washing soda, or mixture of whitewash and paris green.

?ARMY WORM (*Leucania unipuncta* Haw.). Burning over fields in winter; ditching; paris green.

*ASPARAGUS BEETLE, COMMON (*Crioceris asparagi* Linn.). Prompt marketing of all canes; trap plants; dusting with lime or arsenical mixtures; jarring larvæ to ground on hot days, especially if soil be sandy.

*BEAN WEEVIL, COMMON (*Bruchus obtectus* Say). Treating with bisulphide of carbon in air-tight vessels.

*BLACK SCALE (*Lecanium oleæ* Barn.). Kerosene emulsion on young scale or treatment with hydrocyanic acid gas.

BLISTER BEETLES (*Epicauta vittata* Fab., *E. cinerea* Lec., *E. pennsylvanica* De G., *Macrobasis unicolor* Kb.). Arsenicals, 1 pound to 100 gallons of water.

BOLLWORM. (*See* Corn ear worm.)

BUFFALO GNAT (*Simulium pecuarum* Riley). Smudges; oil, grease, etc., applied to stock.

*CABBAGE BUG, HARLEQUIN (*Murgantia histrionica* Hahn). Spring collecting from trap mustard; hand picking.

*CABBAGE WORMS (*Pieris rapæ* Sch., *Plutella cruciferarum* Zell., *Plusia brassicæ* Riley). Pyrethrum; kerosene emulsion; paris green, dry, with flour or lime—1 part of the poison in 50 to 100 of the diluent.

CANKERWORM, SPRING (*Paleacrita vernata* Peck). Arsenical mixtures in spray; trapping female moth in oil troughs or tar bands about trunks of trees.

*CARPET BEETLE, OR "BUFFALO MOTH" (*Anthrenus scrophulariæ* L.). Benzine; hot ironing of carpets over damp cloth; killing by steam.

CHINCH BUG (*Blissus leucopterus* Say). Burning wild grass land and all rubbish in early winter; kerosene emulsion; contagious disease; trap crops; ditching.

?CLOTHES MOTH, SOUTHERN (*Tinea biselliella* Hum.). Brushing and airing; benzine; naphthalene; packing in bags of paper or cotton cloth; cold storage.

*COCKROACH, GERMAN; CROTON BUG (*Phyllodromia germanica* L.). Pyrethrum or buhach; bisulphide of carbon in tight rooms or compartments away from fire.

*CODLING MOTH; APPLE WORM (*Carpocapsa pomonella* Linn.). Arsenicals; first application as soon as blossoms fall; second, one or two weeks later, just before the fruit turns down on the stem; trapping larvæ by applying bands to the tree; prompt destruction of infested fallen fruit.

*COTTON WORM (*Aletia xylina* Say). Paris green dusted on as dry powder.

CORN ROOT WORM (*Diabrotica longicornis* Say). Rotation of corn with oats or other crop.

*CORN STALK BORER, LARGER (*Diatræa saccharalis* F.). Plowing under or burning stubble.

?CORN EAR WORM; BOLLWORM (*Heliothis armiger* Hbn.). Late fall plowing; poisoned baits; for cotton, planting corn as trap crop.

*CURRANT WORM, IMPORTED (*Nematus ribesii* Scop.). Hellebore, 1 ounce to 2 gallons water, in spray.

CUCUMBER BEETLE, STRIPED (*Diabrotica vittata* Fab.). Protecting young plants with netting; arsenicals.

CUTWORMS (Agrotis, Leucania, Mamestra, Hadena, Nephelodes, etc.) Distribution of poisoned green bait; late fall plowing; burning waste tracts and rubbish.

*ELM LEAF BEETLE, IMPORTED (*Galeruca luteola* Müll.). Arsenicals, 1 pound to 100 gallons water, as soon as beetles appear and later for larvæ.

FLEA BEETLE, STRIPED (*Phyllotreta vittata* Fab.). Kerosene emulsion; arsenicals.

*FLUTED SCALE (*Icerya purchasi* Mask.). Introduction of its ladybird enemy, *Novius cardinalis;* hydrocyanic acid gas treatment; soap, 1 pound to 2 gallons hot water.

*FRUIT BARK BEETLE (*Scolytus rugulosus* Ratz.). Burning trap trees and infested trees at any time, but preferably in winter.

*GRAIN WEEVILS (*Calandra granaria* Linn., *C. oryzæ* Linn.). Bisulphide of carbon in bins and granaries; storage in large bulk.

GRAPE PHYLLOXERA (*Phylloxera vastatrix* Planch.). Submersion; bisulphide of carbon, kerosene emulsion, or resin compound about roots; use of resistant stocks.

GRAPEVINE LEAF HOPPER (*Erythroneura vitis* Harr.). Spraying with kerosene emulsion in early morning; catching on tarred shield; cleaning up all leaves and rubbish in fall.

*GYPSY MOTH (*Ocneria dispar* L.). Spraying with arsenicals; hand collecting of cocoons and eggs; oiling egg masses; trapping larvæ.

*HESSIAN FLY (*Cecidomyia destructor* Say). Late planting; selection of wheat less subject to attack; rolling; pasturing to sheep; rotation of crops.

*HOP PLANT LOUSE (*Phorodon humuli* Schr.). Destroying all wild plum trees in vicinity; spraying others in fall or spring with strong kerosene emulsion; spraying vines with kerosene emulsion or fish-oil soap; destroying vines after hops are picked.

*HORN FLY (*Hæmatobia serrata* R.-D.). Application of strong-smelling greases and oils to cattle, or of lime or plaster to dung.

LOCUST, CALIFORNIA DEVASTATING (*Melanoplus devastator* Scudd.). Poisoned bait of bran, sugar, and arsenic.

LOCUST, LESSER MIGRATORY (*Melanoplus atlanis* Riley). (*See* Rocky Mountain locust.)

LOCUST, RED-LEGGED (*Melanoplus femur-rubrum* De G.) (*See* Rocky Mountain locust.)

LOCUST, ROCKY MOUNTAIN (*Melanoplus spretus* Thos.). Catching with hopper-dozers; ditching; burning; rolling; plowing under of eggs.

OX BOT (*Hypoderma lineata* Vill.). Strong-smelling fats and oils applied to cattle.

*OYSTER-SHELL BARK LOUSE (*Mytilaspis pomorum* Bouché). Kerosene emulsion; strong soap or alkali washes.

PEACH-TREE BORER (*Sannina exitiosa* Say). Cutting out the larvæ or scalding them with hot water in late autumn or early spring; painting trunk with arsenicals in thick whitewash; wrapping trunk with grass, paper, etc.

*PEAR-TREE PSYLLA (*Psylla pyricola* Forst.). Kerosene emulsion: First, a winter application diluted seven times; second, in spring as soon as leaves are unfolded, diluted nine times.

PEAR-TREE SLUG (*Eriocampa cerasi* Peck.). Hellebore, 1 ounce to 2 gallons water in a spray; whale-oil soap, 12 pounds to 50 gallons water; arsenicals.

*PEA WEEVIL (*Bruchus pisorum* Linn.). Keeping seed over to second year; bisulphide of carbon in tight vessels.

PLUM CURCULIO (*Conotrachelus nenuphar* Herbst). Arsenical spray: First, before the bloom appears or as soon as foliage starts; second, immediately after blossoms fall; third, a week or ten days after the last; collection of adults from trees by jarring.

POTATO BEETLE, COLORADO (*Doryphora decemlineata* Say). Arsenicals, 1 pound to 100 gallons of water.

*PURPLE SCALE OF THE ORANGE (*Mytilaspis citricola* Pack.). Kerosene emulsion, applied immediately after appearance of new brood.

RICE WATER WEEVIL (*Lissorhoptrus simplex* Say). Draining.

ROSE CHAFER (*Macrodactylus subspinosus* Fab.). Planting spiræas, etc., as trap plants, and collecting beetles in special pans; arsenicals; bagging grapes.

*SAN JOSE SCALE (*Aspidiotus perniciosus* Comst.). Soap wash (2 pounds to the gallon) as soon as leaves fall in autumn; in warm, dry climate, winter resin wash.

*SCREW WORM (*Compsomyia macellaria* Fab.). Prompt burning or burying of dead animals; smearing wounds with fish oil; washing with carbolic acid.

SQUASH BORER (*Melittia ceto* Westw.). Planting early summer squashes to be destroyed; late planting of main crop; destruction of all vines attacked as soon as crop can be gathered; collecting moths.

SQUASH BUG (*Anasa tristis* De G.). Early burning of vines and all rubbish in fall; biweekly collection of eggs.

STRAWBERRY WEEVIL (*Anthonomus signatus* Say). Trap crops; protecting beds with cloth covering; using staminate varieties as fertilizers only and as few plants of the former as necessary; spraying with paris green and bordeaux mixture.

*SUGAR-CANE BORER (*Diatræa saccharalis* Fab.). Burning trash and laying down seed cane under ground.

WEBWORM, FALL (*Hyphantria cunea* Dr.). Prompt removal and destruction of webs and larvæ; arsenical spraying.

WHEAT ISOSOMA (*Isosoma grande* Riley). Burning stubble; rotation of crops.

*WHEAT PLANT LOUSE (*Siphonophora avenæ* Fab.). Rotation of crops.

WHITE GRUB; JUNE BEETLE (*Lachnosterna* spp.). Luring the beetles by lights over tubs into water with skim of kerosene. Against larvæ: Kerosene emulsion; liberal use of potash fertilizers; collecting after the plow.

WIREWORMS (*Drasterius elegans* Fab., *Melanotus fissilis* Say, and *Agriotes* spp.). Fall plowing; poisoned baits; rotation of crops.

PREPARATION AND USE OF INSECTICIDES.

ARSENICALS: PARIS GREEN, SCHEELE'S GREEN, AND LONDON PURPLE.—These three arsenicals practically take the place of all other insecticides for biting and gnawing insects living or feeding on the exterior of plants.

Paris green is a very fine crystalline powder, composed of arsenic, copper, and acetic acid, and costs about 20 cents a pound.

Scheele's green is very similar to paris green in color, and differs from it only in lacking acetic acid. In other words, it is a simple arsenite of copper. It is a much finer powder than paris green, and is therefore more easily kept in suspension, and has the additional advantage of costing only about one-half as much per pound. It is used in the same way and at the same strength as paris green or london purple.

London purple is a waste product in the manufacture of aniline dyes, and contains a number of substances, chief of which are arsenic and lime. It is not as effective as the green poisons, and is apt to scald foliage unless mixed with lime. It costs about 10 cents a pound.

Either of these arsenicals may be used as follows:

The wet method.—Make into a thin paint in a small quantity of water, adding powdered or quick lime equal to the amount of poison used. Strain the mixture into the spray tank. Use either poison at the rate of a pound of dry powder in from 100 to 200 gallons of water. The stronger mixtures are for resistant foliage, such as that of the potato, and the weaker for sensitive foliage, such as that of the peach and plum.

The dry method.—It is ordinarily advisable to use the poison in the form of a spray, but in the case of cotton and some other low crops it may be dusted on the plants. Make the application preferably in early morning or late evening, when the dew is on, to enable the poison to better adhere to the plant. In cotton fields the powder is usually dusted over the plants from bags fastened to each end of a pole, which is carried on horse or mule back. The motion of the animal is sufficient to cause the distribution over the foliage. Garden vegetables may be dusted by hand from bags or powder bellows. For vegetables which are soon to be used as food, mix the poison with 100 times its weight of flour or lime, and apply merely enough to show evenly over the surface.

When to spray.—Spray for the codling moth very soon after the blossoms fall

and again a week or two later, just before the fruit turns down on the stem. This treatment reaches at the same time other leaf-eating insects.

For the curculio, spray as soon as the foliage is well started and again at the time of the exposure of the young fruit by the falling of the blossoms, and a third time a week later, particularly if rains have intervened after the last treatment.

For leaf-feeding insects, spray at the earliest indication of injury, and repeat as often as necessary.

Fruit trees should never be sprayed when in bloom, on account of the liability of poisoning honeybees or other insects useful as cross fertilizers.

ARSENATE OF LEAD.—This arsenical has advantages over paris green, in that it has the merit of showing on the leaves, indicating at once which have been sprayed; remains much more easily suspended in water, and may be used in large proportions without danger to foliage. The insecticide results are not better, however, than in the case of paris green; but for sensitive foliage, or where no risk of scalding may be taken, it will prove useful.

It is prepared by combining, approximately, 3 parts arsenate of soda with 7 parts acetate of lead. From 1 to 10 pounds arsenate of lead are used with 150 gallons of water, 2 quarts of glucose being added to cause it to adhere better to the leaves. From 2 to 5 pounds will answer for most larvæ. The arsenate of lead costs 7 cents a pound wholesale, and glucose $16 a barrel.

ARSENIC BAIT.—It is not always practicable to apply poison directly to plants, and in such cases the use of poison bait is valuable, particularly for cutworms, wireworms, and grasshoppers or locusts.

Bran-arsenic bait.—This is made by combining 1 part by weight of white arsenic, 1 of sugar, and 6 of bran, to which enough water is added to make a wet mash. For grasshoppers or locusts, place a tablespoonful at the base of each tree or vine, or lay a line of it at the head of the advancing army, placing a tablespoonful every 6 to 8 feet, and following this up with another line in front of the first. For baiting cutworms, distribute the mash in small lots over the infested territory.

Green bait.—For the destruction of cutworms and wireworms, use preferably poisoned green succulent vegetation, such as freshly cut clover, distributing it in small bunches about the infested fields. The bunches of green vegetation should be dipped in a strong solution of arsenicals, and prevented from rapid drying by being covered with stones or boards. Renew as often as the bait becomes dry.

In the use of poison bait care must be exercised against its being eaten by domestic animals.

CARBON BISULPHIDE.—This substance, used in tight receptacles, is the cheapest and most effective remedy for all insects affecting stored food and seed material, natural-history specimens, etc., and is one of the best means against insects affecting the roots of plants in loose soils. It is a colorless liquid, with an offensive odor, which soon passes off. It readily volatilizes, and is deadly to insect life. The vapor is highly inflammable and explosive, and should be carefully kept from fire, even a lighted cigar in its proximity being a source of danger. Wholesale, it costs 10 cents a pound; retail, of druggists, 25 to 30 cents a pound.

For root lice of grape, apple, etc., put one-half ounce of bisulphide into holes about plants 10 to 16 inches deep, 1½ feet apart, and not closer to trunk than 1 foot. Make the holes with iron rod and close with foot, or use hand injectors. For root maggots, put a teaspoonful into a hole 2 or 3 inches from the plant and close immediately. For ant nests, pour an ounce of the liquid into each of several holes in the nests; close the opening with the foot or cover with a wet blanket for ten minutes, and then explode the vapor at mouth of holes with torch.

For stored-grain insects, distribute in shallow dishes over the bins; with open bins cover with oilcloth or blankets to retain the vapor. Keep bins or buildings closed for from twenty-four to thirty-six hours; then air them well. Disinfect infested grain in small bins before placing for long storage in large masses.

The bisulphide is applied at the rate of 1 pound to the ton of grain.

HELLEBORE.—White hellebore is used extensively as an insecticide, particularly as a substitute for the arsenites. It kills insects in the same way as an internal poison. It is less dangerous to man and the higher animals than the arsenical poisons, but if sufficient quantity be taken it will cause death. It is particularly useful against the larvæ of sawflies, such as the cherry slug, rose slug, currant worms, and strawberry worms.

It may be applied as a dry powder, preferably diluted with from 5 to 10 parts of flour, and dusted on the plants through a muslin bag or with powder bellows. The application is preferably made in the evening, when the plants are moist with dew. Used as a wet application, it should be mixed with water in the proportion of 1 ounce to the gallon of water and applied as a spray.

In most instances where hellebore is used, the same results may be more cheaply accomplished by using either a soap solution or the arsenicals.

HYDROCYANIC ACID GAS.—This substance is chiefly used to destroy scale insects on fruit trees and nursery stock. The treatment consists in inclosing the tree or nursery stock with a tent and filling the latter with the poisonous gas.

The tents should be of blue or brown drilling, or 8-ounce duck, painted or oiled to make air-tight. The tent may be placed over small trees by hand and over large trees with a tripod or derrick. A tent and derrick for medium-sized trees cost from $15 to $25; for a tree 30 feet tall by 60 feet in circumference, about $60.

Refined potassium cyanide (98 per cent pure), commercial sulphuric acid, and water are used in generating the gas, the proportions being from two-thirds to 1 ounce, by weight, of the cyanide, slightly more than 1 fluid ounce of acid, and 3 fluid ounces of water to every 150 cubic feet of space inclosed.

Place the generator (any glazed earthenware vessel of 1 or 2 gallons' capacity) on the ground within the tent, and add the water, acid, and cyanide, the latter in large lumps, in the order named. The treatment should continue forty minutes. Bright, hot sunlight is apt to cause injury to foliage, and may be avoided by working on cloudy days or at night. One series of tents will answer for a county or large community of fruit growers.

KEROSENE.—Kerosene, or coal oil, is occasionally used directly against insects, although its important insecticide use is in combination with soap or milk emulsion. Under exceptional conditions it may be sprayed directly on living plants, and it has been so used in the growing season without injury. Ordinarily, however, when applied even in the dormant season on leafless plants, it is liable to do serious injury or to kill the plant outright. It is now being used to a certain extent mechanically combined with water in the act of spraying, and is less harmful in this way than when used pure, as it is broken up more finely and somewhat distributed; but the danger of use on tender plants is not avoided by this means. Many insects which can not be destroyed by ordinary insecticides may be killed by jarring them from the plants into pans of water on which a little kerosene is floating, or they may be shaken from the plants onto cloth or screens saturated with kerosene.

For the mosquito, kerosene has proved a very efficient preventive. Applied, at the rate of an ounce to 15 square feet, to the surface of small ponds or stagnant water in which mosquitoes are breeding, it forms a uniform film over the water and destroys all forms of aquatic insects, including the larvæ of the mosquito and the adult females which come to the surface of the water to deposit their eggs. The application retains its efficiency for several weeks.

KEROSENE EMULSIONS.—The kerosene emulsions apply to all such sucking insects as plant bugs, plant lice, scale insects, thrips, and plant mites, and to such biting insects as can not be safely poisoned.

Kerosene and soap emulsion formula.

Kerosene	gallons	2
Whale-oil soap (or 1 quart soft soap)	pounds	1–2
Water	gallon	1

Dissolve the soap in water by boiling, and add boiling hot, away from the fire, to the kerosene. Agitate violently for five minutes by pumping the liquid back upon itself with a force pump and direct-discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. The mixture will have increased about one-third in bulk, and assumed the consistency of cream. Well made, the emulsion should keep indefinitely, and should be diluted only as wanted for use.

In limestone or hard-water regions "break" the water with lye before using to make or dilute the emulsion, or use rainwater. Better than either, use the milk emulsion, with which the character of the water does not affect the result.

Kerosene and milk emulsion formula.

Kerosene	gallons	2
Milk (sour)	gallon	1

Heating is unnecessary; churn as in the former case for three to five minutes, or until a thick, buttery consistency results. Prepare the milk emulsion from time to time for immediate use, unless it can be stored in air-tight jars; otherwise it will soon ferment and spoil.

How to use the emulsions.—For summer applications for most plant lice and other soft-bodied insects, dilute with 15 to 20 parts of water; for the red spider and

other plant mites, the same, with the addition of 1 ounce of powdered sulphur to the gallon; for scale insects, the larger plant bugs, larvæ, and beetles, dilute with 7 to 9 parts water.

For subterranean insects, such as root lice, root maggots, "white grubs," etc., use either kerosene emulsion or resin wash, wetting the soil to the depth of 2 to 3 inches, and follow with copious waterings, unless in rainy season.

NAPHTHALENE.—This substance is used principally for the repellent action due to the vapor it exhales at the ordinary temperature of the air. In the form of cubes, cones, or globes it is used to protect clothing from the ravages of moths. Placed with stored-seed products, it will protect them from various weevils and stored-grain pests. It has no effect on the germination of the seed. Naphthalene is also quite universally employed to preserve natural-history specimens from museum pests. The vapors of naphthalene are fatal to insects, but the vapor of bisulphide of carbon is much quicker in action, and to be preferred.

OILS: FISH OIL, TRAIN OIL, AND COTTON-SEED OIL.—These are sometimes used on domestic animals to rid them of vermin, and fish oil is one of the best-known repellents for the horn fly, buffalo gnat, and ox bot fly. Any of these oils or any grease, the more strong smelling the better, thinly smeared on animals at the points of attack by flies, will afford great protection. They are also valuable against lice affecting live stock, but must be used carefully, or they may cause the hair to fall off.

PYRETHRUM, OR INSECT POWDER.—This insecticide is sold under the names of buhach and Persian insect powder.

It acts on insects externally, through their breathing pores, and is fatal to many forms. It is not poisonous to man or the higher animals, and hence may be used where poisons would be objectionable. Its chief value is against household pests, such as roaches, flies, and ants, and in greenhouses, conservatories, and small gardens, where the use of poisons would be inadvisable.

It is used as a dry powder, pure or diluted with flour, when it may be puffed about rooms or wherever insects may occur. When used on plants, it is preferably applied in the evening. As a preventive, and also as a remedy for the mosquito, burning the powder in a tent or room will give satisfactory results. It may also be used as a spray, at the rate of 1 ounce to 3 gallons of water, but in this case should be mixed up some twenty-four hours before being applied. For immediate use a decoction may be prepared by boiling in water from five to ten minutes.

RESIN WASH.—This is valuable for scale insects wherever the occurrence of comparatively rainless seasons insures the continuance of the wash on the trees for a considerable period, and as winter washes in very mild climates, as southern California, or wherever the multiplication of the insect continues almost without interruption throughout the year.

Formula for resin wash.

Resin	pounds	20
Caustic soda (70 per cent)	do	5
Fish oil	pints	2½
Water to make	gallons	100

Ordinary commercial resin is used, and the soda is that put up for soap establishments in large 200-pound drums. Smaller quantities may be obtained at soap factories, or the granulated caustic soda (98 per cent) used, 3½ pounds of the latter being the equivalent of 5 pounds of the former. Place these substances with the oil in the kettle, with water to cover them to a depth of 3 or 4 inches. Boil from one to two hours, occasionally adding water, until the compound resembles very strong black coffee. Dilute to one-third the final bulk with hot water or with cold water added slowly over the fire, making a stock mixture, to be diluted to the full amount as used. When sprayed, the mixture should be perfectly fluid and without sediment, and should any appear in the stock mixture reheating should be resorted to. For a winter wash, dilute one-third or one-half less.

SOAPS AS INSECTICIDES.—Any good soap is effective in destroying soft-bodied insects, such as plant lice and young or soft-bodied larvæ. The soaps made of fish oil, and sold under the name of whale-oil soaps, are especially valuable. For plant lice and delicate larvæ, such as the pear slug and others, a strength obtained by dissolving half a pound of soap in a gallon of water is sufficient. Soft soap will answer as well as hard, but at least double quantity should be taken.

As winter washes, the fish-oil soaps have proved the most effective means of destroying certain scale insects, and have been of especial service against the very resistant San Jose scale.

For winter applications, use the soap at the rate of 2 pounds to a gallon of water, making the application with a spray pump as soon as the leaves fall in the autumn, repeating, if necessary, in spring before the buds unfold.

SULPHUR.—Flowers of sulphur is one of the best remedies for plant mites, such as the "red spider," six-spotted orange mite, rust mite of the orange fruit, etc. Applied at the rate of 1 ounce to a gallon of water, or mixed with some other insecticide, such as kerosene emulsion, it is a very effective remedy. For the rust mite, sprinkling the powdered sulphur about under the trees is sometimes sufficient to keep the fruit bright. Sulphur is often used to rid poultry houses of vermin, and when fed to cattle is said to be a good means of ridding them of lice; or it may be mixed with grease, oil, etc., and rubbed into the skin.

Bisulphide of lime.—This chemical is even better than sulphur as a remedy for mites, but it is a liquid and can be diluted easily to any extent. It can be made very cheaply by boiling together in a small quantity of water equal parts of lime and flowers of sulphur. For mites, take 5 pounds of sulphur and 5 of lime, and boil in a small quantity of water until both are dissolved and a brownish liquid results. Dilute to 100 gallons.

TAR.—This substance is commonly used as a repellent by dissolving in water and sprinkling the plants with the solution. It is also sometimes smeared in and about the nostrils of sheep, to prevent the bot fly from depositing its eggs. Painted on paper bands wrapped around the bases of fruit trees, and renewed before becoming dry, it will entrap the wingless female cankerworm moths in their attempts to ascend the trees for the purpose of depositing eggs. Pine tar is preferable to coal tar, but neither kind should be applied directly to the bark. A prepared grease, known as insect lime, is now generally employed instead of tar.

A CHEAP ORCHARD-SPRAYING OUTFIT.

Spraying to control various insect pests, particularly those of the orchard and garden, has reached so satisfactory and inexpensive a basis that it is recognized by every progressive farmer as a necessary feature of the year's operations, and in the case of the apple, pear, and plum crops the omission of such treatment means serious loss. The consequent demand for spraying apparatus has been met by all the leading pump manufacturers of this country, and ready-fitted apparatus, consisting of pump, spray tank or barrel, and nozzle with hose, are on the market in numerous styles and at prices ranging from $20 upward. The cost of a spraying outfit for orchard work may, however, be considerably reduced by purchasing merely the pump and fixtures and mounting them at home on a strong barrel. An apparatus of this sort, representing a style that has proved very satisfactory in practical experience, is illustrated in the accompanying figure (164). It is merely a strong pump with an air-chamber to give a steady stream provided with two discharge hose pipes. One of these enters the barrel and keeps the water agitated and the poison thoroughly intermixed, and the other and longer one is the spraying hose and terminates in the nozzle. The spraying hose should be about 20 feet long, and may be fastened to a light pole, preferably of bamboo, to assist in directing the spray. The nozzle should be capable of breaking the water up into a fine mist spray, so as to wet the plant completely with the least possible expenditure of liquid. A suitable pump with nozzle and hose may be obtained of any hardware dealer.

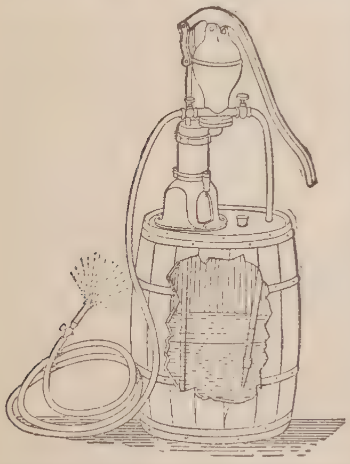


FIG. 164.—Orchard-spraying apparatus.

SEED STANDARDS.

The following standards of purity and germination in seeds are recommended by the Department of Agriculture. The term *purity*, the percentage of which is reckoned by weight, denotes freedom from foreign matter, such as chaff, dirt, or seeds of other plants, but it has no reference to the genuineness of the variety, which is called by seedsmen purity of stock. The percentage of *germination* is reckoned by count from a sample freed from foreign matter, a seed being

considered as having germinated when the rootlet, or radicle, has pushed through the seed coat. It is not to be understood from these standards that the real value of a quantity of seed is dependent wholly upon the number of pure germinable seeds it contains. The ancestry of the seed and its trueness to type are factors of primary importance in determining seed value, especially in the case of vegetables. These points, however, are very difficult, if not impossible, to determine at the time of purchase, while the purity and germination are easily ascertained and are very essential points. The germination standards are based upon tests conducted between moist blotters in a germinating chamber. Such tests usually give a little higher result than those made in soil. In the case, however, of blue grass, lettuce, tobacco, and the parsley family, soil tests are generally higher than blotter tests. While the figures given are only tentative and subject to change, it should be stated that they are the result of all the information available at the present time, including nearly ten thousand germination tests conducted in the seed laboratory of the Department of Agriculture.

Per cent of purity and germination of seeds.

Seed.	Purity.	Germination.	Seed.	Purity.	Germination.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Alfalfa	98	85–90	Melon, musk	99	85–90
Asparagus	99	80–85	Melon, water	99	85–90
Barley	99	90–95	Millet, common (*Setaria*		
Beans	99	90–95	*italica*)	99	85–90
Beet	99	[1] 150	Millet, hog (*Panicum milia-*		
Blue grass, Canadian	90	45–50	*ceum*)	99	85–90
Blue grass, Kentucky	90	45–50	Millet, pearl	99	85–90
Brome, awnless	90	75–80	Mustard	99	90–95
Buckwheat	99	90–95	Oats	99	90–95
Cabbage	99	90–95	Okra	99	80–85
Carrot	95	80–85	Onion	99	80–85
Cauliflower	99	80–85	Parsley	99	70–75
Celery	98	60–65	Parsnip	95	70–75
Clover, alsike	95	75–80	Peas	99	93–98
Clover, crimson	98	85–90	Pumpkin	99	85–90
Clover, red	98	85–90	Radish	99	90–95
Clover, white	95	75–80	Rape	99	90–95
Collard	99	90–95	Rye	99	90–95
Corn, field	99	90–95	Salsify	98	75–80
Corn, sweet	99	85–90	Sorghum	98	85–90
Cotton	99	85–90	Spinach	99	80–85
Cowpea	99	85–90	Spurry	99	85–90
Cress	99	85–90	Squash	99	85–90
Cucumber	99	85–90	Timothy	98	85–90
Eggplant	99	75–80	Tomato	98	85–90
Fescue, meadow	95	85–90	Turnip	99	90–95
Lettuce	99	85–90	Tobacco	98	75–80
Kafir corn	98	85–90	Wheat	99	90–95

[1] Each beet fruit, or "ball," is likely to contain from 2 to 7 seeds. One hundred balls should yield at least 150 sprouts.

TREATMENT FOR FUNGOUS DISEASES OF PLANTS—FORMULAS FOR FUNGICIDES.

In the following table the plants affected are arranged alphabetically, and in columns opposite each name are given the number of times and methods of making the various treatments. Following the names of the fungicides are small numbers, which refer to the formulas for making them. The formulas follow the table.

Fungous diseases of plants and methods of treatment.

Disease.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Remarks.
Almond or apricot shot-hole fungus.	Ammoniacal copper carbonate solution (1) when leaves unfold.	Same fungicide ten or twelve days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later, if necessary.	....	
Apple scab........	Bordeaux mixture (2), 60-gallon formula, when fruit buds are unfolding.	Same fungicide when flower clusters are expanding.	Same fungicide when petals are falling.	Same fungicide when fruit is one-half inch in diameter, if wet weather prevails.	Same fungicide two weeks later, if wet weather prevails.	Paris green may be combined with the fungicide in a proportion of 4 ounces to every 50 gallons of the mixture, to prevent ravages of codling moth.
Barley smut........	Soak seed in cold water four hours.	Place in sacks and leave for four hours.	Soak seed in water at a temperature of 126° to 128° for five minutes.	....	....	
Cherry leaf blight..	Bordeaux mixture (2), 60-gallon formula, after foliage is fully developed.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	Same fungicide fourteen days later.	A sixth application may be necessary. The treatment is especially applicable to nursery stock, and the endeavor should be made to keep the upper and lower surfaces of the newly developing foliage covered with the fungicide.
Cherry and plum black knot.	Bordeaux mixture (2), 22-gallon formula, before leaves appear.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	....	The knots should be cut off and burned whenever possible. Painting the cut surfaces with kerosene or linseed oil will tend to prevent the return of the knots.
Grape black rot....	Bordeaux mixture (2), 50-gallon formula, before buds open.	Same fungicide when leaves are one-third grown.	Same fungicide just before blooming.	Same fungicide two weeks later.	Ammoniacal copper carbonate solution (1), two weeks later.	A sixth application may be necessary, and it should be made with ammoniacal copper carbonate solution. In dry weather it is probable that the number of sprayings may be less.
Grape downy mildew.	Bordeaux mixture (2), 60-gallon formula, when leaf buds open.	Same fungicide when leaves are half grown.	Same fungicide when plants are in bloom.	Same fungicide when fruit is half grown.	....	As this disease and black rot frequently occur together, the same applications will generally answer for both. If more than four applications be made, as may be necessary in wet seasons, ammoniacal copper carbonate solution should be used to prevent spotting the fruit.

Fungous diseases of plants and methods of treatment—Continued.

Disease.	First application.	Second application.	Third application.	Fourth application.	Fifth application.	Remarks.
Oat smut	Soak seed for one minute in warm water at 110° (3).	Soak seed in hot water at 132° for ten minutes.				After the second soaking, if not needed for immediate use, the seed should be spread out to dry and then put in clean bags, which have been previously sterilized by heat.
Orange sooty mold.	Resin wash (4) in January or February.	Same wash ten days to two weeks later.	Same wash in May or August.			Special care should be taken to wet the under surfaces of the leaves. Usually two sprayings in winter are sufficient.
Peach curl	Bordeaux mixture (2), 50-gallon formula, just before buds unfold.	Same fungicide when leaves are half grown.	Same fungicide two weeks later.	Same fungicide two weeks later.		
Pear leaf blight	Bordeaux mixture (2), 50-gallon formula, when buds are swelling.	Same fungicide when leaves are half grown.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	This is especially for the nursery. In the orchard the first and second treatments may be omitted.
Pear scab	Bordeaux mixture (2), 50-gallon formula, when fruit buds open.	Same fungicide just before blossoming.	Same fungicide when petals fall.	Same fungicide when fruit is one-half inch in diameter.		
Plum, prune, and peach leaf rust.	Ammoniacal copper carbonate solution (1) when trees cease to bloom and when in leaf.	Same fungicide three weeks later.	Same fungicide two weeks later.			
Potato rot or blight and Macrosporium disease.	Bordeaux mixture (2), 22-gallon formula, when plants are 6 inches high.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.		For best results potatoes should be dug as soon as plants wither, not allowing them to remain in the ground until cold weather.
Potato scab	Cut and soak potatoes in corrosive sublimate solution (5) one hour and thirty minutes.					
Quince fruit spot and leaf blight.	Bordeaux mixture (2), 60-gallon formula, after blossoms fall.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	Same fungicide two weeks later.	A sixth application may be necessary in case of very wet weather.
Wheat stinking smut.	Soak seed for one minute in warm water at 110° to 115° (3).	Soak seed for fifteen minutes in hot water (132°).	Cool seed with cold water and spread out to dry.			

FORMULAS FOR FUNGICIDES.

(1) *Ammoniacal copper carbonate solution:*

Copper carbonate	ounces	5
Ammonia (26 per cent)	pints	3
Water	gallons	50

Place the copper carbonate in a wooden pail and make a paste of it by the addition of a little water. Then pour on the ammonia and stir until all the copper is dissolved. If the 3 pints of ammonia is not sufficient to dissolve the copper, add more until no sediment remains. Pour into a barrel and dilute with 45 or 50 gallons of water, and the mixture is then ready for use.

(2) *Bordeaux mixture:*

Copper sulphate	pounds	6
Strong fresh lime	do	4
Water	gallons	22

In a barrel that will hold 45 gallons dissolve the copper sulphate, using 8 or 10 gallons of water, or as much as may be necessary for the purpose. In a tub or half barrel slack the lime. When completely slacked, add enough water to make a creamy whitewash. Pour this slowly into the barrel containing the copper sulphate solution, using a coarse gunny sack stretched over the head of the barrel for a strainer. Finally, fill the barrel half full of water, stir thoroughly, and the mixture is ready for use. The 50 or 60 gallon formula is made in the same way, except that 50 or 60 gallons of water is added instead of 22 gallons. For further directions in making large quantities, see Bulletin No. 6, Division Vegetable Physiology and Pathology, pp. 8–11.

(3) *Hot-water treatment:*

This treatment is used for smuts of oats and wheat. Place two large kettles or two wash boilers on a stove; provide a reliable thermometer, and a coarse sack or basket for the seed. A special vessel for holding the grain may be made of wire or perforated tin. A vessel should never be entirely filled with grain, and in the kettles there should be about five or six times as much water by bulk as there is grain in the basket. In the first kettle keep the temperature of the water at from 110° to 130° and in the other at 132° to 133°, never letting it fall below 130° lest the fungous spores may not be killed, nor rise above 135° lest the grain be injured. Place the grain in the basket and then sink it into the first kettle. Raise and lower it several times or shake it so that all the grain may become wet and uniformly warm. Remove it from the first kettle and plunge it into the second, where it should receive fifteen minutes' treatment. Shake about repeatedly and also raise the basket containing the grain completely out of the water five or six times during the treatment. If the temperature falls below 132°, let the basket remain a few moments longer; if it rises, a few moments less. Have at hand cold and boiling water with which to regulate the temperature. At the expiration of fifteen minutes remove the grain and plunge into cold water, after which spread it out to dry. The seed may be sown at once, before thoroughly dry, or may be dried and stored until ready for use. In treating oats keep them in water at 132° for only ten minutes and spread out to dry without plunging into the cold water.

(4) *Resin wash:*

Resin	pounds	20
Caustic soda (98 per cent)	do	4½
Fish oil (crude)	pints	3
Water to make	gallons	15

Place the resin, caustic soda, and fish oil in a large kettle. Pour over them 13 gallons of water and boil until the resin is thoroughly dissolved, which requires from three to ten minutes after the materials begin to boil. While hot add enough water to make just 15 gallons. When this cools, a fine, yellowish precipitate settles to the bottom of the vessel. The preparation must therefore be thoroughly stirred each time before measuring out to dilute, so as to uniformly mix the precipitate with the clear, dark, amber-brown liquid, which forms by far the greater part of the stock preparation. When desired for use, take 1 part of the stock preparation to 9 parts of water. If the wash be desired for immediate use, the materials, after boiling and while still hot, may be poured directly into the spray tank and diluted with cold water up to 150 gallons.

(5) *Corrosive sublimate solution:*

Corrosive sublimate	ounces	$2\frac{1}{4}$
Water	gallons	15

This solution is used for potato scab. The corrosive sublimate is dissolved in about 2 gallons of hot water, and after an interval of ten or twelve hours diluted with 13 gallons of water. The potatoes to be planted are immersed in the solution for one and one-half hours, after which they are spread out to dry, then cut and planted as usual. A half barrel is a convenient receptacle for the solution. The potatoes may be put into a coarse sack and suspended in the liquid, first washing the tubers. Corrosive sublimate is very poisonous and should be kept out of the way of children and animals. All treated tubers should be planted, or, if not planted, destroyed.

Potassium sulphide:

Potassium sulphide	ounces	$2\frac{1}{2}$
Water	gallons	5

Dissolve the potassium sulphide in water, and the mixture is ready for use.

ERRONEOUS IDEAS CONCERNING HAWKS AND OWLS.

Much misapprehension still exists among farmers as to the habits of birds of prey. Examination of the contents of the stomachs of such birds, to the number of several thousand, has established the fact that their food consists almost entirely of injurious mammals and insects, and that accordingly these birds are in most cases positively beneficial to the farmer, and should be fostered and protected.

Among those *wholly beneficial* are the large, rough-legged hawk; its near relative, the squirrel hawk, or ferruginous roughleg, and the four kites—the white-tailed kite, Mississippi kite, swallow-tailed kite, and everglade kite.

The class that is *beneficial in the main*—that is, whose depredations are of little consequence in comparison with the good it does—includes a majority of the hawks and owls, among them being the following species and their races: Marsh hawk, Harris's hawk, red-tailed hawk, red-shouldered hawk, short-tailed hawk, white-tailed hawk, Swainson's hawk, short-winged hawk, broad-winged hawk, Mexican black hawk, Mexican goshawk, sparrow hawk, Audubon's caracara, barn owl, long-eared owl, short-eared owl, great gray owl, barred owl, Western owl, Richardson's owl, Acadian owl, screech owl, flammulated screech owl, snowy owl, hawk owl, burrowing owl, pygmy owl, ferruginous pygmy owl, and elf owl.

The class in which the *harmful and the beneficial* qualities about balance each other includes the golden eagle, bald eagle, pigeon hawk, Richardson's hawk, Aplomado falcon, prairie falcon, and great horned owl.

The *harmful* class comprises the gyrfalcons, duck hawk, sharp-shinned hawk, Cooper's hawk, and goshawk.

The investigations upon which the foregoing statements are based were described at considerable length in the Yearbook of the U. S. Department of Agriculture for 1894.

TIMBER—LUMBER—WOOD.

QUALITY.

Sapwood is light and weak if from an old tree, but heavy and strong if from a young tree.

Sapwood shrinks more and decays more easily than heartwood.

A young tree makes heavier and stronger wood than an old tree, hence second growth is often better than old timber.

The butt cut of hard pine weighs 20 per cent more and is 30 per cent stronger than the top cut.

The heaviest stick of the same kind, when seasoned, is the strongest; a piece of seasoned pine weighing 45 pounds to the cubic foot is one-third to one-half stiffer and stronger than one weighing 30 pounds.

Broad-ringed oak and pine, with broad, dark bands of summer wood, are strongest.

Crossgrain and knots reduce both stiffness and strength.

A crossgrained piece will scarcely support one-twentieth of the load that a straight-grained piece of the same kind will support.

EFFECTS OF SEASONING.

A cord of green wood weighs 50 per cent more than when air dry.

A cord of well-dried wood still contains 600 pounds of water.

In the burning of green wood, nearly one-half the heat is lost in evaporating the water contained in it.

One-half the weight of fresh, sappy pine is due to water. The kiln-drying of lumber, at a small expense, saves 1,000 to 1,500 pounds of freight per 1,000 feet, B. M.

Seasoning increases stiffness and strength by about 50 per cent.

Checks produced in drying decrease the value of timber; seasoning, therefore, always injures as well as benefits.

Wood always swells and shrinks—that is, takes up and gives off water—hence the periodic recurrence of cracks in floors, etc.

Split wood shrinks more evenly, sheds water and wears better than if sawed.

Good hard pine shrinks about 6 inches per 100 inches width of flooring when laid green; good red oak about 9 inches.

A "quarter-sawed" board shrinks only one-half to two-thirds as much as a bastard-sawed one.

Wood shrinks inappreciably in length, 3 to 6 per cent in radial direction (across the rings), and 4 to 10 per cent in tangential direction (with the rings).

Quarter-sawed boards and bastard-sawed boards neither shrink nor wear alike; hence for the best floors they should not be used side by side.

STIFFNESS AND STRENGTH.

Doubling the length of a board or timber reduces the stiffness eightfold and the strength one-half.

Doubling the width of a board doubles the stiffness and strength.

Doubling the thickness of a board or the depth of a timber increases the stiffness about eightfold and the strength fourfold.

If, therefore, it is desired to double the length and retain the same stiffness, it is necessary to double the thickness or depth.

Weight for weight, a stick of pine is stronger and stiffer than a solid iron or steel of same shape and length.

A joist 2 by 6 inches is three times as stiff as one 2 by 4. A joist 2 by 8 inches is eight times, and one 2 by 12 is twenty-seven times, as stiff.

A good hard-pine joist 2 by 4 inches and 10 feet long may support 2,000 pounds in the middle, but it can safely be trusted only to the extent of 400 pounds.

If weighted suddenly, a timber bends much more than if weighted gradually with the same weight.

A timber projecting from the wall and weighted at the end (a cantilever) supports only as much as a timber twice the length resting on both ends and weighted in the middle.

MEASUREMENT.

A cord of body wood closely piled contains 100 cubic feet of solid wood; if one-third limbs, not more than 80 cubic feet.

A cord of good oak wood contains 175 to 200 billets, requires about a dozen small-sized trees (8 to 10 inches diameter) or one good-sized tree (20 to 24 inches) to make it, and weighs about 2.5 tons.

To obtain, approximately, the volume of a standing tree, measure the circumference breast-high in feet, square it, divide by 25, and multiply by the estimated height, the result being in cubic feet. For saw timber, take estimated length of log instead of height of tree.

To obtain volume of standing timber per acre, count and classify trees of same diameter and height, measure one of each class, multiply by the number of trees in the class, and add the results.

Summary of log-book estimates for memorizing.

Diameter of log in inches	10		12		14		16		18		20		22		24
Number of feet, B. M., contained in 10 feet of length	20		40		60		90		120		160		200		250
Difference in feet		20		20		30		30		40		40		50	

It will be observed that the increase in diameter from 10 inches to 12 and from 12 inches to 14 is accompanied, in each case, by an increase of 20 feet in the contents of the log; that the increase from 14 inches to 16 and from 16 inches to 18 is accompanied, in each case, by an increase of 30 feet in the contents of the log, and that the increase from 18 inches to 20 and from 20 inches to 22 represents, in each case, an addition of 40 feet to the contents of the log. The reader can follow out this ratio of increase as circumstances require.

DISTANCE TABLE FOR TREE PLANTING.

Number of trees that may be set upon a piece of land 100 yards or feet square on a side, in right-angled rows of equal and unequal distances apart.

Yds. or ft. between trees in the rows.	Yards or feet between rows.														
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	9.0	10.0
0.5	20,000	13,333	10,000	8,000	6,667	5,714	5,000	4,444	4,000	3,636	3,333	2,857	2,500	2,222	2,000
1.0	10,000	6,667	5,000	4,000	3,333	2,857	2,500	2,222	2,000	1,818	1,666	1,428	1,250	1,111	1,000
1.5	6,667	4,444	3,333	2,667	2,222	1,905	1,667	1,481	1,333	1,212	1,111	952	833	740	666
2.0	5,000	3,333	2,500	2,000	1,667	1,429	1,250	1,111	1,000	909	833	714	625	555	500
2.5	4,000	2,667	2,000	1,600	1,333	1,143	1,000	889	800	727	666	571	500	444	400
3.0	3,333	2,222	1,667	1,333	1,111	952	833	741	667	606	555	476	416	370	333
3.5	2,857	1,905	1,429	1,143	952	816	714	635	571	519	476	408	357	317	285
4.0	2,500	1,667	1,250	1,000	833	714	625	556	500	455	416	357	312	277	250
4.5	2,222	1,481	1,111	889	741	635	556	494	444	404	370	317	277	246	222
5.0	2,000	1,333	1,000	800	667	571	500	444	400	364	333	285	250	222	200
5.5	1,818	1,212	909	727	606	519	455	404	364	333	303	259	227	202	181
6.0	1,667	1,111	833	667	556	476	417	370	333	303	277	238	208	185	166
6.5	1,538	1,026	769	615	513	440	385	342	308	280	256	219	192	170	153
7.0	1,429	952	714	571	476	408	357	317	286	260	238	204	178	158	142
7.5	1,333	889	667	533	444	381	333	296	267	242	222	190	166	148	133
8.0	1,250	833	625	500	417	357	313	278	250	227	208	178	156	138	125
8.5	1,176	784	588	471	392	336	294	261	235	219	196	168	147	130	117
9.0	1,111	741	556	494	370	317	278	247	222	202	185	158	138	123	111
10.0	1,000	667	500	400	333	286	250	222	200	100	166	142	125	111	100

In order to find number of trees needed per acre divide the above figures by 2, if they have been read as referring to feet; multiply them by 4⅓ if they have been read as referring to yards. This will give the number needed within an unappreciable error.

IRRIGATION.

A water right is the right or privilege of using water for irrigating purposes, either in a definite quantity or upon a prescribed area of land, such right or privilege being customarily acquired either by priority of use or by purchase. In many parts of the arid region a water right is an exceedingly valuable property. The average value of the water rights of the entire arid region, as determined by the Census of 1890, was $26 per acre, and there are fruit-growing districts in California where water rights have been sold at as high as $1,500 per miner's inch, or from $100 to $500 per acre, according to the amount used on any given area of land.

The duty of water is the extent of the service it will perform when used for irrigating purposes, that is, the number of acres a given quantity of water will adequately irrigate under ordinary circumstances. This is usually from 100 to 200 acres for each second-foot. Where water is abundant, the duty has been known to be as low as 50 acres, and, where very scarce, as high as 500 acres to the second-foot.

A miner's inch is theoretically such a quantity of water as will flow through an aperture 1 inch square in a board 2 inches thick under a head of water of 6 inches in one second of time, and it is equal to 0.194 gallon, or 0.0259337 cubic foot per second, or to 11.64 gallons, or 1.556024 cubic feet, per minute. The amount of water flowing through a given aperture in a given time varies, however, with the head of water over the opening and also with the form of the opening. In Colorado the miner's inch legalized by statute equals 11.7 gallons per minute. The California miner's inch, however, equals only 9 gallons per minute, 100 Colorado inches being, accordingly, equal to 130 California inches. One hundred Colorado

inches will cover an acre to a depth of 5.2 feet in twenty-four hours; 100 California inches will cover the same area only to a depth of 4 feet in the same time. Fifty California inches are therefore, approximately, equal to 1 second-foot, and 50 Colorado inches to about three-tenths more.

An acre-foot of water is the amount required to cover an acre of ground to a depth of 1 foot. This is 43,560 cubic feet, or 325,851.4512 gallons. Its weight is 1,213 tons 2,113 pounds, at 2,240 pounds to the ton.

The amount of water required to cover an acre of ground to a depth of 1 inch is 3,630 cubic feet, or 27,154.2876 gallons. Its weight is 101 tons $362\frac{3}{4}$ pounds, at 2,240 pounds to the ton.

A second-foot is the most satisfactory, because the most definite, unit of measurement for flowing water. It is used by the United States Government in the gauging of rivers and streams, and is rapidly superseding the miner's inch in the measurement of water for irrigation. It is the quantity represented by a stream 1 foot wide and 1 foot deep, flowing at the average rate of 1 foot per second. In other words, it is 1 cubic foot per second, 60 cubic feet per minute, 3,600 cubic feet per hour, and so on. A stream flowing continuously at the average rate of 1 second-foot would carry in one day of twenty-four hours 86,400 cubic feet, or 646,316.928 gallons, sufficient to cover $1\frac{119}{121}$ acres to a depth of 1 foot. Flowing continuously for one year of three hundred and sixty-five days, such a stream would carry 31,536,000 cubic feet, or 235,905,678.72 gallons, sufficient to cover $723\frac{117}{121}$ acres to a depth of 1 foot.

The subhumid region is the strip of country running north and south between the arid region, where irrigation is absolutely necessary to the successful prosecution of agriculture, and those portions of the United States in which the rainfall is usually sufficient for agricultural purposes. It includes portions of North Dakota, South Dakota, Nebraska, Kansas, and Texas, and may be described as a region where irrigation is not always necessary, but where agricultural operations can not, with any assurance of success, be undertaken without it.

The average value of the irrigated land in farms in the United States was ascertained by the Census of 1890 to be \$83.28 per acre, and that of the nonirrigated land in farms \$20.95 per acre.

The average annual value of the agricultural products of the irrigated land was ascertained to be \$14.89 per acre irrigated, and that of those of the nonirrigated land \$6.80 for each acre improved.

The average first cost of the irrigated land, including purchase money, water rights, etc., was ascertained to have been \$8.15 per acre, and the average annual cost of the water supply \$1.07 per acre.

The total value of the irrigated farms of the United States, as reported by the farmers themselves, was, in round figures, \$296,850,000, an increase of \$219,360,000, or 283.08 per cent, upon their cost, including land, water rights, fences, and preparation for cultivation.

The total value of the productive irrigating systems was found to be \$94,412,000, an increase of \$64,801,000, or 218.84 per cent, upon their cost.

NUMBER, WEIGHT, COST OF GRASS SEEDS, AND AMOUNT TO SOW PER ACRE.

Number of grains in 1 pound of seed of the principal grasses and forage plants, the amount to sow per acre of seed of standard purity, the amount to sow of pure and germinating seed, the weight per bushel, the cost of seed per acre, and the weight of 10,000,000 seeds, which is the standard amount per acre in composing mixtures.

[Columns 1, 2, 3, and 4 are compiled from The Best Forage Plants, by Stebler & Schroeter. The figures in column 5 are obtained by multiplying the amount of standard quality of seed required (column 2) by the retail price per pound quoted in New York catalogues. The weight of 10,000,000 grains (column 6) is obtained by dividing this quantity by the number of seeds in 1 pound (column 1).]

Name.	(1) Number of grains in 1 pound of pure seed.	(2) Amount to sow per acre, in pounds, standard quality.	(3) Amount to sow per acre, in pounds, of pure germinating seed.	(4) Weight per bushel.	(5) Cost of seed per acre.	(6) Weight of 10,000,000 grains.	Remarks.
				Pounds.		*Pounds.*	
Redtop (*Agrostis alba*)	603,000	9.7	7.00	8-32	$1.45	16.58	Requires moist climate or damp soil. Best propagated by transplanting small turf cuttings in autumn. Valuable for late pasturage or lawns in the New England and Middle States. Use 5 to 10 per cent in mixtures.
Reed canary grass (*Phalaris arundinacea*).	660,000	21.0	12.00	44-48	7.35	15.15	Adapted to stiff, wet lands and flooded fields. Requires moisture. Valuable hay when cut young, and well suited for binding loose banks near running water or for forming a firm sod on marshy ground.
Smooth-stalked meadow grass (*Poa pratensis*).	2,400,000	17.5	8.40	....	2.10	4.17	Grows best on soils which are strongly calcareous. Well adapted for pasture, and makes a good bottom grass for meadows. An excellent lawn grass.
Rough-stalked meadow grass (*Poa trivialis*).	3,000,000	19.5	8.75	11-17	4.88	3.33	Should be sown only on moist, fertile, and sheltered soils in mixtures.
Sheep's fescue (*Festuca ovina*).	680,000	28.0	12.60	10-15	4.20	14.85	Light, dry soils, especially those which are poor, shallow, and silicious. Valuable bottom grass and for sheep pastures. Sown only in mixtures.
Various-leafed fescue (*Festuca heterophylla*).	400,000	33.5	19.50	....	8.38	25.00	Best on moist, low lands containing humus, and sandy loams. Withstands drought; useful in pasture; unimportant for hay. Alone it makes no continuous turf.
Creeping fescue (*Festuca rubra*).	600,000	42.5	13.00	10-15	8.50	16.66	Valuable pasture or bottom grass. Withstands drought; endures both cold and shade. On poor land, especially moist sands and railway banks, serves to bind the soil. Product small.
Awnless brome grass (*Bromus inermis*).	137,000	44.0	35.60	....	8.80	72.99	Valuable for light soils, especially in regions subject to extremes of heat or long periods of drought. Used alone or in mixtures for permanent meadows and pastures.
Perennial rye grass (*Lolium perenne*).	336,800	55.0	38.50	18-30	4.95	29.70	Excellent and lasting pasture grass for heavy soils in moist, cool climates. On light, dry soils disappears after the second year. Rarely sown alone.

Italian rye grass (*Lolium italicum*).	285,000	48.5	32.40	12-24	3.56	35.10	Excellent for rich and rather moist lands. Regarded in Europe as one of the best for hay. Lasts only 2 or 3 years.
Orchard grass (*Dactylis glomerata*).	579,500	35.0		12-16	5.60	17.25	Grows well on any soil, excepting that which is very wet; withstands shade. Affords a great amount of aftermath. Valuable alike for hay and pasturage.
Meadow fescue (*Festuca pratensis*).	318,200	52.0		12-26	7.80	31.42	Thrives in either dry or wet soils. Valuable hay or pasture grass.
Meadow oat grass (*Arrhenatherum avenaceum*).	159,000	70.0	34.30	10	12.60	62.89	Thrives on moist, loamy sands, or light clays which are not too moist, and marls. Spring most favorable seed time. Valuable in the South for hay or winter pasture.
Yellow oat grass (*Trisetum flavescens*).	2,045,000	29.0	4.64	5⅓	24.65	4.89	Valuable for temporary or permanent pastures. Thrives on marly or calcareous soil, in all light land rich in humus.
Velvet grass (*Holcus lanatus*).	1,304,000	22.0	8.80	6½	4.40	7.66	Sometimes sown on light, thin soils, unsuited for more valuable sorts. Rarely used excepting in mixtures.
Timothy (*Phleum pratense*)	1,170,500	16.0	14.00	48	1.50	8.54	Best known and most extensively cultivated for hay, sown alone or mixed with redtop or clover. Succeeds best on moist loams or clays. On dry ground the yield is light.
Meadow foxtail (*Alopecurus pratensis*).	907,000	23.0	6.21	6	6.21	11.02	Endures cold. Likes strong soil, stiff loam or clay. One of the best for land under irrigation. Very early. Two to four pounds in mixtures for permanent pastures.
Vernal grass (*Anthoxanthum odoratum*).	924,000	30.0	7.80		15.00	10.82	Grows on almost any kind of soil; sown only in mixtures, 1 to 2 pounds with permanent pasture or meadow grasses.
Crested dog's tail (*Cynosurus cristatus*).	1,127,000	25.0	13.50	20-32	7.50	8.87	Especially adapted for loams, light clays, marls, and moist, loamy sands. Moist climates are most suitable; withstands drought and thrives well in shade. Nutritive value high. Used in mixtures to form bottom grass either in pasture or hay.
Alsike clover (*Trifolium hybridum*).	707,000	12.3	9.00	94-100	1.60	14.14	Grows on strongest clay or peaty soil; peculiarly adapted to damp ground. Bears heavy frosts without injury. Sow in August or February.
Sainfoin (*Onobrychis sativa*).	22,500	[1] 78.0	[1] 60.84	40	6.25	444.44	Requires good and open subsoil, free from water. Sown alone, from end of March to beginning of May.
Red clover (*Trifolium pratense*).	279,000	18.0	15.84	64	2.50	35.84	Succeeds best in rich, loamy soil, on good clays, and on soils of an alluvial nature. A standard fodder plant.
White clover (*Trifolium repens*).	740,000	10.5	7.50	63	2.94	13.51	Thrives on mellow land containing lime, and on all soils rich in humus. Resists drought. Generally used in mixtures for pastures or lawns.
Common kidney vetch (*Anthyllis vulneraria*).	154,000	17.5	15.00	60-64	4.58	67.15	Cultivated for grazing; on warm soils, if manured and of proper depth. Hardy; resists drought. Sheep, goats, and horned cattle eat it greedily.
Alfalfa, or lucern (*Medicago sativa*).	209,500	25.0	22.00	61-63	3.25	48.56	Grows well on any calcareous soil having a permeable subsoil. Especially adapted to the warm and dry regions of the West and Southwest. Requires irrigation.
Trefoil (*Medicago lupulina*).	328,000	18.0	14.75	64-66	2.16	30.48	Any soil containing sufficient moisture and lime is suitable. Most successful on clay marls. Cultivated only where the better kinds of clover can not be grown.
Bird's-foot trefoil (*Lotus corniculatus*).	375,000	11.0	4.67	60	4.40	26.66	Thrives on dry or moist, sandy or clayey soils. Well suited to dry lands at high elevations, though poor.
Officinal goats' rue (*Galega officinalis*).	62,000	22.0	6.90		4.14	161.29	Excellent fodder plant for warm, sheltered situations. Thrives only in deep soil, and when subsoil is not wet.

[1] Unshelled.

Weight and cost of the seed of four mixtures, each designed to cover an acre, upon the basis of 10,000,000 plants, compiled from table on page 632.

	Mixture.	Number of seeds.	Pounds.	Cost.
A.	Timothy	6,700,000	5.72	$0.57
	Alsike	1,650,000	2.33	.30
	White clover	1,650,000	2.23	.62
	Total	10,000,000	10.28	1.49
B.	Timothy	5,000,000	4.27	.43
	Kentucky blue grass	1,000,000	.41	.05
	Orchard grass	700,000	1.21	.19
	Alsike	1,650,000	2.33	.30
	White clover	1,650,000	2.23	.62
	Total	10,000,000	10.45	1.59
C.	Timothy	4,000,000	3.42	.34
	Kentucky blue grass	1,200,000	.50	.06
	Orchard grass	1,000,000	1.73	.28
	Meadow foxtail	500,000	.55	.15
	Alsike	1,650,000	2.33	.30
	White clover	1,650,000	2.23	.62
	Total	10,000,000	10.76	1.75
D.	Red clover	2,790,000	10.00	1.40
	Alsike	2,121,000	3.00	.39
	Timothy	3,089,000	2.64	.26
	Redtop	2,000,000	3.31	.40
	Total	10,000,000	18.95	2.45

THE METRIC SYSTEM.

The entire metric system of weights and measures is based upon a fundamental unit called a meter, which is the ten-millionth part of the distance from the equator to the pole, and is the principal unit of linear measure.

The are, or unit of square measure, is a square whose side is 10 meters.

The stere, or unit of cubic measure, is a cube whose edge is a meter.

The liter, or unit of all measures of capacity, is a cube whose edge is the tenth of a meter.

The gram, or unit of weight, is the weight of a cube of pure water at its greatest density, the edge of which is the hundredth part of a meter.

Elements of the system.

Length.	Surface.	Capacity.	Weight.	Notation.
			Metric ton.	1,000,000
			Quintal.	100,000
Myriameter.			Myriagram.	10,000
Kilometer.		Kiloliter.	Kilogram.	1,000
Hectometer.	Hectare.	Hectoliter.	Hectogram.	100
Decameter.	Decare.	Decaliter.	Decagram.	10
Meter.	*Are.*	*Liter.*	*Gram.*	1
Decimeter.		Deciliter.	Decigram.	0.1
Centimeter.	Centiare.	Centiliter.	Centigram.	0.01
Millimeter.		Milliliter.	Milligram.	0.001

The metric system has been made compulsory in France, Germany, Austria-Hungary, Belgium, Spain, Portugal, Italy, Norway, Sweden, Switzerland, Servia, Roumania, Mexico, Brazil, Peru, Venezuela, and Argentina. In Great Britain, Japan, and the United States the system is legalized, but its use is not compulsory. Russia and Denmark stand alone in not having taken any action, but even these countries are contributors to the International Bureau of Weights and Measures.

In all the different countries in which this system has been adopted the change from the systems previously in use was made without the slightest difficulty, but it is hardly necessary to point out that unless the metric system had been

distinguished by great simplicity it would not have commended itself to so large a number of the nations of the world, with all their various peculiarities and prejudices. Its superior character, both as regards simplicity and scientific precision, was recognized in the United States at an early day, and as long ago as 1866 Congress legalized the system in this country and authorized the Secretary of the Treasury to distribute to each State of the Union a set of metric standards of weights and measures, which was done. It has since authorized on different occasions the participation of the United States Government in the various operations that have been advocated by the International Bureau of Weights and Measures.

Our present system has for its sole recommendation that it has been in common use for many years. It is irrational in theory and irksome in practice, and is almost entirely without authorization in the history of Congressional legislation.

Linear, or long, measure.

Denomination.	Meters.	Inches.	Feet.	Yards.	Miles.
Millimeter	0.001	0.03937	0.00328	0.00109	
Centimeter	.01	.3937	.03280	.01094	
Decimeter	.1	3.937	.32808	.10936	0.00006
Meter	1	[1]39.37	3.28083	1.09361	.00062
Decameter	10		32.80833	10.93611	.00621
Hectometer	100		328.0833	109.3611	.06214
Kilometer	1,000		3,280.833	1,093.611	.62137
Myriameter	10,000				6.2137

[1]39.37 inches is the legalized equivalent of the meter in the United States.

Square measure.

Denomination.	Square meters.	Square inches.	Square feet.	Square yards.	Acres.
Milliare	0.1	155	1.0764	0.1196	
Centiare, or square meter	1	1,550	10.764	1.196	
Deciare	10		107.64	11.96	0.0025
Are, or square decameter	100		1,076.4	119.6	.0247
Decare	1,000			1,196	.2471
Hectare	10,000				2.471

A square centimeter equals 0.155 square inch, a square decimeter 15.5 square inches, and a square kilometer 0.386 square mile.

Cubic measure.

Denomination.	Cubic meters.	Cubic inches.	Cubic feet.	Cubic yards.
Millistere, or cubic decimeter	0.001	61.023	0.03531	
Centistere	.01	610.233	.35314	0.01308
Decistere	.1		3.53144	.1308
Stere, or cubic meter	1		35.3144	1.308
Decastere	10		353.144	13.08
Hectostere	100			130.8

Measure of capacity.

Denomination.	Liters.	Fluid ounces.	Quarts.	Gallons.	Bushels.
Milliliter, or cubic centimeter	0.001	0.0338	0.00106		
Centiliter	.01	.338	.01057	0.00264	
Deciliter	.1	3.38	.10567	.02642	0.00284
Liter, or cubic decimeter	1	33.8	1.0567	.26417	.02837
Decaliter	10	338	10.567	2.6417	.28377
Hectoliter	100		105.67	26.417	2.83774
Kiloliter, or cubic meter	1,000			264.17	28.3774
Myrialiter	10,000			2,641.7	283.774

A liter is the weight of a kilogram of distilled water at its maximum density.

Weight.

Denomination.	Grams.	Grains.	Ounces avoirdupois.	Pounds avoirdupois.	Tons of 2,240 pounds.
Milligram	0.001	0.01543			
Centigram	.01	.15432			
Decigram	.1	1.54324	0.00353		
Gram	1	15.43236	.03527	0.0022	
Decagram	10	154.32356	.35274	.02205	
Hectogram	100	1,543.2356	3.5274	.22046	
Kilogram	1,000	15,432.356	35.274	2.20462	0.00098
Myriagram	10,000			22.0462	.00984
Quintal	100,000			220.462	.09842
Millier, or tonne	1,000,000			2,204.62	.9842

NOTES REGARDING DEPARTMENT PUBLICATIONS.

The publications of the U. S. Department of Agriculture are of three classes: (1) Serial publications, (2) scientific and technical reports, and (3) popular bulletins. The first two classes are issued in limited editions and are distributed free only to persons cooperating with or rendering the Department some service. Sample copies will be sent if requested, but miscellaneous applicants to receive the same regularly or for occasional copies must apply to the Superintendent of Documents, Union Building, Washington, D. C., to whom all publications not needed for official use, except circulars and bulletins printed by law for free distribution, are turned over in accordance with the following provision of the act providing for the public printing and binding and distribution of public documents:

"SECTION 67. All documents at present remaining in charge of the several Executive Departments, bureaus, and offices of the Government not required for official use shall be delivered to the Superintendent of Documents, and hereafter all public documents accumulating in said Departments, bureaus, and offices not needed for official use shall be annually turned over to the Superintendent of Documents for distribution or sale."

The popular circulars and bulletins treat in a practical way of subjects of particular interest to farmers, are issued in large editions, and are for free distribution. Under this class are included the Farmers' Bulletins, of which the following are available, and for which applications should be addressed to the Secretary of Agriculture, Washington, D. C., stating both the number and title of the publication desired:

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. No. 16. Leguminous Plants for Green Manuring and for Feeding. No. 17. Peach Yellows and Peach Rosette. No. 18. Forage Plants for the South. No. 19. Important Insecticides: Directions for their Preparation and Use. No. 20. Washed Soils: How to Prevent and Reclaim Them. No. 21. Barnyard Manure. No. 22. Feeding Farm Animals. No. 23. Foods: Nutritive Value and Cost. No. 24. Hog Cholera and Swine Plague. No. 26. Sweet Potatoes: Culture and Uses. No. 27. Flax for Seed and Fiber. No. 28. Weeds, and How to Kill them. No. 29. Souring of Milk and Other Changes in Milk Products. No. 30. Grape Diseases on the Pacific Coast. No. 31. Alfalfa, or Lucern. No. 32. Silos and Silage. No. 33. Peach Growing for Market. No. 34. Meats: Composition and Cooking. No. 35. Potato Culture. No. 36. Cotton Seed and Its Products. No. 37. Kafir Corn: Characteristics, Culture, and Uses. No. 38. Spraying for Fruit Diseases. No. 39. Onion Culture. No. 40. Farm Drainage. No. 41. Fowls: Care and Feeding. No. 42. Facts about Milk. No. 43. Sewage Disposal on the Farm and the Protection of Drinking Water. No. 44. Commercial Fertilizers: Composition and Use. No. 45. Some Insects Injurious to Stored Grain. No. 46. Irrigation in Humid Climates. No. 47. Insects Affecting the Cotton Plant. No. 48. The Manuring of Cotton. No. 49. Sheep Feeding. No. 50. Sorghum as a Forage Crop. No. 51. Standard Varieties of Chickens. No. 52. The Sugar Beet.

The Department has no list to whom all publications are sent. The Monthly List of Publications, issued the first of each month, will be mailed to all who apply for it. In it the titles of the publications are given, with a note explanatory of the character of each, thus enabling the reader to make intelligent application for such bulletins and reports as are certain to be of interest to him.

For the maps and bulletins of the Weather Bureau, requests and remittances should be directed to the Chief of that Bureau. For all publications to which a price is affixed, application must be made to the Superintendent of Documents, Union Building, Washington, D. C., accompanied by the price thereof, and all remittances should be made to him and not to the Department of Agriculture, and

such remittances should be made by postal money order and not by private check or postage stamps.

The Superintendent of Documents is not permitted to sell more than one copy of any public document to the same person.

PUBLICATIONS ISSUED JULY 1, 1895, TO DECEMBER 31, 1896.

The following publications were issued by the United States Department of Agriculture during the period July 1, 1895, to December 31, 1896.

Those to which a price is attached, with the exception of publications of the Weather Bureau, must be obtained of the Superintendent of Documents, Union Building, Washington, D. C., to whom were turned over all copies not needed for official use, in compliance with section 67 of the act providing for the public printing and binding and the distribution of public documents. Remittances should be made to him by postal money order. Applications for those that are for free distribution should be made to the Secretary of Agriculture, Washington, D. C.:

OFFICE OF THE SECRETARY.	Copies.
Yearbook of the Department of Agriculture for 1894. Pp. 608, pls. 7, figs. 140. September, 1895. Price 50 cents	500,000
Yearbook of the Department of Agriculture for 1895. Pp. 656, pls. 10, figs. 134. June, 1896. Price 55 cents	500,000
The World's Markets for American Products—Great Britain and Ireland. Pp. 93, fig. 1. Bulletin No. 1. August, 1895. Price 5 cents	5,000
The World's Markets for American Products—Great Britain and Ireland. Pp. ii, 95–155. Supplement to Bulletin No. 1. (Reprint.) August, 1895. Price 5 cents	10,000
The World's Markets for American Products—The German Empire. Pp. 91, pl. 1. Bulletin No. 2. (Reprint.) August, 1895. Price 5 cents	5,000
The World's Markets for American Products—France. Pp. 74. Bulletin No. 3. July, 1895. Price 5 cents	15,000
Reprint. September, 1895	5,000
The World's Markets for American Products—Canada. Pp. 67. Bulletin No. 4. September, 1895. Price 5 cents	15,000
Reprint, May, 1896	1,000
The World's Markets for American Products—Netherlands. Pp. 76. Bulletin No. 5. October, 1895. Price 5 cents	15,000
The World's Markets for American Products—Belgium. Pp. 90. Bulletin No. 6. December, 1895. Price 5 cents	7,000
Reprint, December, 1896	500
The World's Markets for American Products—Norway. Pp. 68, 1 map. Bulletin No. 7. July, 1896. Price 5 cents	4,000
The World's Markets for American Products—Sweden. Pp. 92. Bulletin No. 8. November, 1896. Price 5 cents	4,000
American Dried Apples in the German Empire. Pp. 4. Circular No. 2. July, 1895	10,000
Reprint, February, 1896	2,500
Imports and Exports for 1893 and 1894. Pp. 4. Circular No. 3. August, 1895	50,000
An Example for American Farmers and Dairymen. Pp. 3. Circular No. 4. September, 1895	10,000
Reprint, February, 1896	2,500
Imports and Exports for 1893, 1894, and 1895. Pp. 6. Circular No. 6. November, 1895	15,000
Reprint, January, 1896	20,000
The Treaty of Shimonoseki between China and Japan of April 17, 1895, and Our Possibilities of Trade with Those Countries. Pp. 7. Circular No. 5. November, 1895	10,000
Report of the Secretary of Agriculture, 1895. (Preliminary.) Pp. 64. November, 1895	50,000
Letter of the Secretary of Agriculture, transmitting, in answer to a resolution of the Senate of the 12th instant, a statement of the expenditures from the appropriation for the purchase and distribution of valuable seeds, made by the act of March 2, 1895; and also a copy of each bid made to the Department of Agriculture to furnish it with seeds, bulbs, cuttings, etc. Pp. 30. Senate Doc. No. 40, 54th Cong., 1st sess. January, 1896	1,000
Report of the Secretary of Agriculture; being part of the Message and Documents communicated to the two Houses of Congress at the beginning of the first session of the Fifty-fourth Congress. Pp. 266, chart 1, January, 1896	3,000

	Copies.
Tobacco: Instructions for its Cultivation and Curing. By John M. Estes, Special Agent. Pp. 8. Farmers' Bulletin No. 6. (Reprint.) January, 1896	10,000
Reprint, May, 1896	10,000
Reprint, October, 1896	20,000
Extension of Markets for American Feed Stuffs. Pp. 8. Circular No. 7. February, 1896	10,000
Letter from the Secretary of Agriculture, transmitting a detailed statement of the expenditures of all appropriations for the Department of Agriculture for the fiscal year ended June 30, 1895, including supplemental account to date. Pp. 180. Document No. 25, 54th Cong., 1st sess. February, 1896	602
Arbor Day: Its History and Observance. By N. H. Egleston. Pp. 80, figs. 28. March, 1896	10,000
The Manchester District of England as a Market for American Products. Pp. 8, fig. 1. Circular No. 8. March, 1896	10,000
Washed Soils: How to Prevent and Reclaim Them. Pp. 22, figs. 6. Farmers' Bulletin No. 20. (Reprint.) April, 1896	20,000
Reprint, August, 1896	20,000
Statement in Regard to Award of Seed Contract. Pp. 8. April, 1896	7,000
Vivisection in the District of Columbia. By Chas. W. Dabney, jr., Acting Secretary. Pp. 4. May, 1896	12,000
Progress of Southern Agriculture. By Chas. W. Dabney, jr., Assistant Secretary of Agriculture. Pp. 12. June, 1896	25,000
Work of the Department of Agriculture as Illustrated at the Atlanta Exposition. By Robert E. Wait, Private Secretary to Assistant Secretary of Agriculture. Pp. 503-522, pls. 8-10, fig. 129, from Yearbook for 1895. June, 1896	500
Canadian Field Peas. By Thomas Shaw, Professor of Animal Husbandry, College of Agriculture of the University of Minnesota. Pp. 223-232, from Yearbook for 1895. June, 1896	200
Soil Ferments Important in Agriculture. By H. W. Wiley, Chief of the Division of Chemistry.—Origin, Value, and Reclamation of Alkali Lands. By E. W. Hilgard, Professor of Agriculture and Agricultural Chemistry, University of California.—Reasons for Cultivating the Soil. By Milton Whitney, Chief of the Division of Agricultural Soils.—Humus in Its Relation to Soil Fertility. By Harry Snyder, Professor of Agricultural Chemistry in the University of Minnesota. Pp. iii, 69-142, pl. 2, figs. 7, from Yearbook for 1895. June, 1896	400
Irrigation for the Garden and Greenhouse. By L. R. Taft, Professor of Horticulture, Michigan Agricultural College.—The Health of Plants in Greenhouses. By B. T. Galloway, Chief of the Division of Vegetable Physiology and Pathology. Pp. iii, 233-256, figs. 49-56, from Yearbook for 1895. June, 1896	800
The Civil Service in the Department of Agriculture. Pp. 4. Circular No. 5. July, 1896	2,500
Reprint, August, 1896	5,000
Imports and Exports for 1893, 1894, 1895. Circular No. 9. October, 1896	30,000
Reprint, November, 1896	20,000
Course of Wheat Production and Exportation in the United States, Canada, Argentina, Uruguay, Russia, and British India from 1880 to 1896. Pp. 8. Circular No. 10. October, 1896	50,000
Report of the Secretary of Agriculture, 1896. (Preliminary.) Pp. 51. November, 1896	30,000

DIVISION OF ACCOUNTS AND DISBURSEMENTS.

Report of the Chief of the Division of Accounts and Disbursements for 1895. By F. L. Evans. Pp. iii, 245-264, from Message and Documents, Department of Agriculture, 1895. January, 1896	500

AGRICULTURAL SOILS.

Soil Moisture: A Record of the Amount of Water Contained in Soils during the Month of May, 1895. Pp. 16, figs. 14. Bulletin No. 1. September, 1895. Price 5 cents	26,000

	Copies.
Soil Moisture: A Record of the Amount of Water Contained in Soils during the Month of June, 1895. Pp. 16, figs. 19. Bulletin No. 2. October, 1895. Price 5 cents	26,000
Soil Moisture: A Record of the Amount of Water Contained in Soils during the Month of July, 1895. Pp. 23, diagrams 20. Bulletin No. 3. January, 1896. Price 5 cents	600
Tobacco Soils of Connecticut and Pennsylvania. By Milton Whitney, Chief of the Division of Agricultural Soils. Pp. iii, 143–155, figs. 4–10, from Yearbook for 1894. September, 1895	3,000
Conditions in Soils of the Arid Region. By Milton Whitney, Chief of the Division of Agricultural Soils. Pp. iii, 155–164, fig. 11, from Yearbook for 1894. September, 1895	5,000
Truck Lands of the Atlantic Seaboard. By Milton Whitney, Chief of the Division of Agricultural Soils. Pp. iii, 129–143, figs. 1–3, from Yearbook for 1894. September, 1895	5,000
Methods of the Mechanical Analysis of Soils and of the Determination of the Amount of Moisture in Soils in the Field. Pp. 24, fig. 1. Bulletin No. 4. May, 1896. Price 5 cents	1,200
Reasons for Cultivating the Soil. By Milton Whitney, Chief of the Division of Agricultural Soils. Pp. 123–130, from Yearbook for 1895. June, 1896	200
Texture of Some Important Soil Formation. Pp. 23, pls. 35. Bulletin No. 5. July, 1896	2,000

DIVISION OF AGROSTOLOGY.

Alfalfa, or Lucern. By Jared G. Smith, Assistant Agrostologist. Pp. 23, figs. 3. Farmers' Bulletin No. 31. August, 1895	25,000
Reprint, October, 1895	25,000
Reprint, February, 1896	40,000
Reprint, June, 1896	20,000
Reprint, October, 1896	30,000
A Note on Experimental Grass Gardens. By Jared G. Smith, Acting Agrostologist. Pp. 4. Circular No. 1. August, 1895	10,000
Grasses as Sand and Soil Binders. By F. Lamson-Scribner, B. Sc., Agrostologist. Pp. iii, 421–436, figs. 100–110, from Yearbook for 1894. August, 1895	500
Giant Knotweed, or Sachaline. By F. Lamson-Scribner, Agrostologist. Pp. 4, figs. 3. Circular No. 5. (Reprint.) October, 1895	5,000
Hairy Vetch, Sand Vetch, or Russian Vetch (*Vicia villosa*). By F. Lamson-Scribner, Agrostologist. Pp. 4, fig. 1. Circular No. 2. October, 1895	10,000
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DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

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Bordeaux Mixture: Its Chemistry, Physical Properties, and Toxic Effects on Fungi and Algæ. By Walter T. Swingle, Assistant, Division of Vegetable Physiology and Pathology. Pp. 37. Bulletin No. 9. July, 1896	1,200
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Report of the Chief of the Weather Bureau for 1895. By Willis L. Moore. Pp. iii, 65-96, from Message and Documents, Department of Agriculture, 1895. January, 1896	8,000
Statistics of State Weather Services. By Oliver L. Fassig, Librarian. Pp. 12. February, 1896	600
The Determination of the Relative Quantities of Aqueous Vapor in the Atmosphere by Means of the Absorption Lines of the Spectrum. By L. E. Jewell, under the general supervision of Prof. H. A. Rowland, of Johns Hopkins University. Pp. 12, fig. 1. Bulletin No. 16. February, 1896	1,000
Injury from Frost and Methods of Protection. By W. H. Hammon, Forecast Official. Pp. 12. April, 1896	7,000
The Work of the Weather Bureau in Connection with the Rivers of the United States. Pp. 106, diagrams 3. Bulletin No. 17. May, 1896	500
Departures from Normal Temperatures and Rainfall, with Crop Yields in Nebraska. By Maj. H. H. C. Dunwoody, assigned to duty as Acting Assistant Chief. Pp. 30, charts 10. (Quarto.) May, 1896	1,000
Report of the Fourth Annual Meeting of the American Association of State Weather Services Cooperating with the Weather Bureau, U. S. Department of Agriculture, held at Indianapolis, Ind., October 16 and 17, 1895. Pp. 55. Bulletin No. 18. May, 1896. Price 5 cents	5,000
Report of the International Meteorological Congress, held at Chicago, Ill., August 21-24, 1893, under the auspices of the Congress Auxiliary of the World's Columbian Exposition. Bulletin 11, Part 3. Pp. xix-xxi, 585-772, pls. 26-43, fig. 1. Edited by Oliver L. Fassig, Secretary. November, 1896	1,000
Daily Weather Map, showing weather conditions throughout the United States and giving forecasts of probable changes.	
Temperatures Injurious to Food Products in Storage and during Transportation, and Methods of Protection from the Same. By H. E. Williams, Chief of Forecast Division. Pp. 20. Bulletin No. 13. (Reprint.) August, 1896	1,000

APPROPRIATIONS FOR THE U. S. DEPARTMENT OF AGRICULTURE FOR THE FISCAL YEARS ENDING JUNE 30, 1896 AND 1897.

APPROPRIATIONS, 1896.

Salaries, Department of Agriculture		$252,840.00
Collecting agricultural statistics		110,000.00
Inquiries relating to public roads		10,000.00
Botanical investigations and experiments		25,000.00
Investigating the history and habits of insects		20,000.00
Investigations in ornithology and mammalogy		17,500.00
Pomological information		6,000.00
Microscopical investigations		2,000.00
Vegetable pathological investigations and experiments		20,000.00
Laboratory, Department of Agriculture		14,900.00
Report on forestry		25,000.00
Illustrations and engravings		15,000.00
Document and folding room		2,000.00
Experimental gardens and grounds		29,500.00
Quarantine stations for neat cattle		12,000.00
Purchase and distribution of valuable seeds	$130,000	
Farmers' Bulletins	50,000	185,400.00
Printing	5,400	
Experiments in the manufacture of sugar		10,000.00
Agricultural experiment stations [$750,000] [1]		30,000.00
Irrigation investigations		15,000.00
Nutrition investigations		15,000.00
Investigations and experiments with grasses and forage plants		15,000.00
Investigations in relation to agricultural soils		15,000.00
Furniture, cases, and repairs		10,000.00
Postage		2,000.00
Museum		3,000.00
Fiber investigations		5,000.00
Library		6,000.00
Contingent expenses		25,000.00
Salaries and expenses, Bureau of Animal Industry		800,000.00
Total		1,698,140.00

Weather Bureau.

Salaries	164,290.00
Fuel, lights, and repairs	8,000.00
Contingent expenses	10,000.00
General expenses	703,320.00
Total for Weather Bureau	885,610.00
Grand total	2,583,750.00

APPROPRIATIONS, 1897.

Salaries, Department of Agriculture	$313,860.00
Furniture, cases, and repairs, Department of Agriculture	12,000.00
Library, Department of Agriculture	7,000.00
Museum, Department of Agriculture	3,000.00
Postage, Department of Agriculture	3,000.00
Contingent expenses, Department of Agriculture	25,000.00
Animal quarantine stations	12,000.00
Collecting agricultural statistics	110,000.00
Botanical investigations and experiments	15,000.00
Entomological investigations	20,000.00
Vegetable pathological investigations	20,000.00
Biological investigations	17,500.00
Pomological investigations	6,000.00
Laboratory, Department of Agriculture	12,400.00
Forestry investigations	20,000.00
Experimental gardens and grounds, Department of Agriculture	20,000.00
Soil investigations	10,000.00
Grass and forage plant investigations	10,000.00
Fiber investigations	5,000.00
Agricultural experiment stations [$750,000] [1]	30,000.00
Nutrition investigations	15,000.00
Public road inquiries	8,000.00
Publications, Department of Agriculture	70,000.00
Purchase and distribution of valuable seeds	150,000.00
Salaries and expenses, Bureau of Animal Industry	650,000.00
Total	1,564,760.00

Weather Bureau.

Salaries, Weather Bureau	150,540.00
Fuel, lights, and repairs, Weather Bureau	8,000.00
Contingent expenses, Weather Bureau	8,000.00
General expenses, Weather Bureau	717,232.00
Total for Weather Bureau	883,772.00
Grand total	2,448,532.00

[1] Of this amount, $720,000 is paid directly to the experiment stations by the United States Treasury.

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